Connecting People and Nature in Biosphere Regions

by

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Abstract

The United Nations Educational, Scientific and Cultural Organization (UNESCO Man) and the Biosphere Programme was established in 1971 to “establish a scientific basis for enhancing the relationship between people and their environments.” Currently, there are 759 biosphere reserves across 136 countries worldwide in the World Network of Biosphere Reserves (WNBR). These biospheres carry out three key functions: conservation, sustainable development, and logistic support. They connect people and nature, sustaining the beauty and benefits of healthy lands and waters. Within the United States, the Biosphere Network (USBN) includes 28 biospheres, providing invaluable landscape conservation and sustainable development at local and regional levels.

Biospheres must undergo a periodic review every ten years, submitting reports to the UNESCO International Coordinating Council of the WNBR for verification of their activity and function. With many U.S. biospheres due for review in 2026 and 2027, the University of Michigan SEAS capstone team was tasked with providing technical assistance to strengthen capacity and prevent the network from losing any biosphere regions.

The capstone team’s work was divided into four deliverables: an ArcGIS StoryMap, a qualitative community needs assessment, a gender inclusivity research paper, and a climate resiliency report. The comprehensive StoryMap and shapefile geodatabase capture biosphere success stories across the nation and aid in submission of region boundaries to UNESCO. Qualitative assessments of the network and its 28 reserves aid in preservation, expansion, and inform a strategic roadmap for future development. A research paper on gender inclusivity in the U.S. Biosphere Network examines gaps and begins dialogue for future programming, aligning with UNESCO’s priority of gender equality. The climate resiliency report aligns research, action, and education efforts to promote collaboration and highlight the program's value for climate action. These deliverables form a toolkit to help the U.S. Biosphere Regions navigate periodic reviews, conservation and sustainable economic development.

Acknowledgments

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Picture from Left to Right: Mary Kolleth, Sarah Davis, Alaina Smith, Rongkai Zhong, Sean Skinner, Samuel Kocurek, Craig Reiley

Chapter 1: The United States Biosphere Network and Man and Biosphere Programme

The United Nations Educational, Scientific and Cultural Organization (UNESCO) Man and the Biosphere Programme (MAB) began with the purpose of formalizing research to connect people to places. The term biosphere comes from the writings of geologist Eduard Suess, meaning the sum of all living things and the spaces they occupy. While the program itself uses the terminology of biosphere "reserves" many biospheres have elected to use the term "region" instead, to better reflect the mission and nature of the program. The technical guidelines define the program's purpose as providing logistical support for conservation and socio-ecologically sustainable development in its regions. In contrast to fortress conservation practices, biosphere regions are not strictly protected areas but include areas with living, working communities and partners dedicated to furthering the program's mission. There are currently 759 biosphere reserves across 136 countries, with 28 located in the United States.

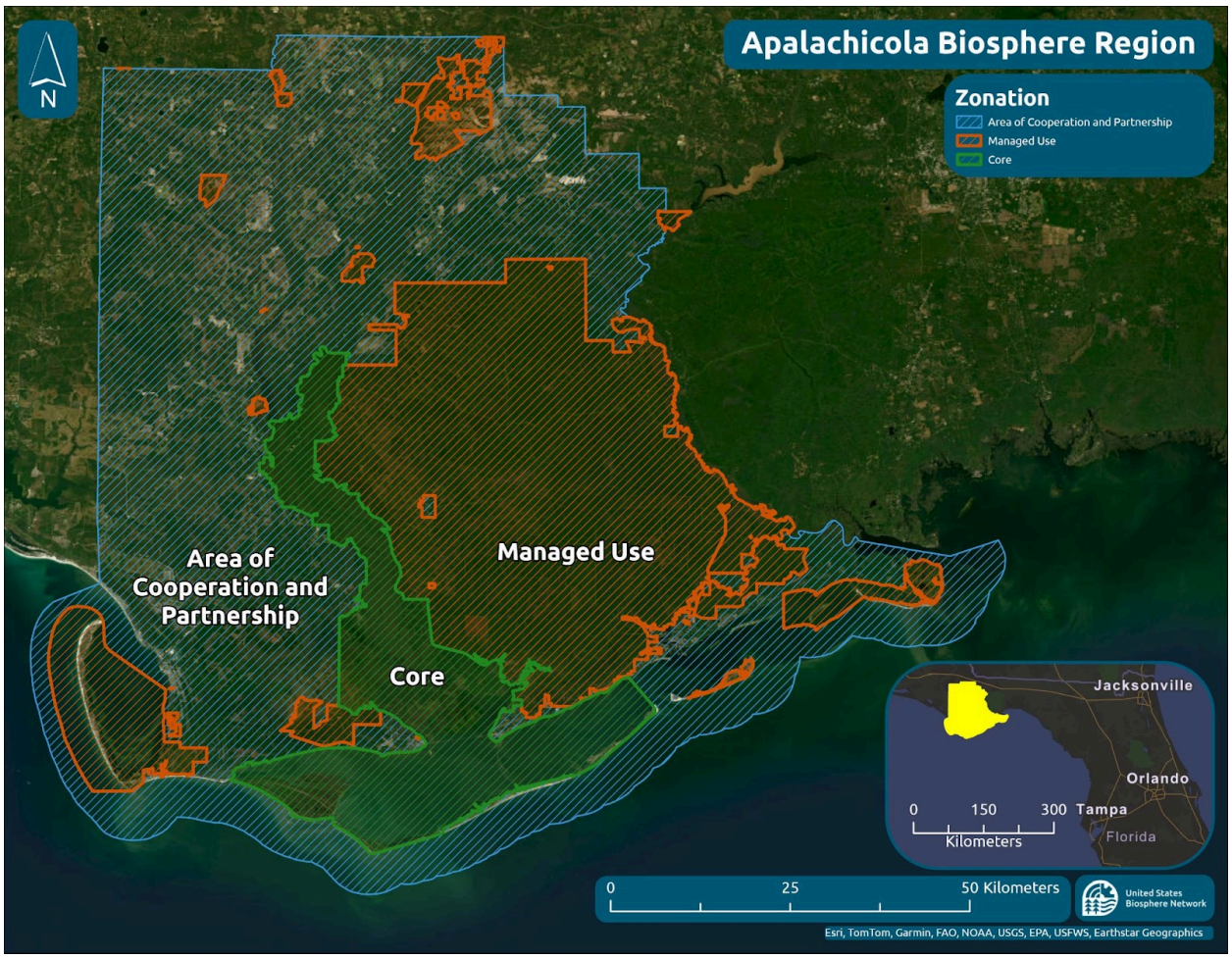


Figure 1: Apalachicola Biosphere Region Map

Biospheres are spatially organized into three geographic areas:

1. Core Areas are strictly protected biodiverse zones that focus on the conservation function of the biosphere. In the United States biosphere regions, many core areas are National Parks or National Forests.
2. The Managed Use Area is used for research, training, and education, where all activities must be compatible with sound ecological practices, but strict protections are not in place.
3. The Area of Cooperation and Partnership is focused on the function of socio- and ecological sustainable development. These are areas with residents hosting a range of economic and human activities.

UNESCO refers to these areas the Core, Buffer, and Transition Zones. The United States Biosphere Network (USBN) adopted the above nomenclature, which UNESCO accepts as compatible vernacular for the U.S.

Biospheres are organizationally structured as voluntary and cooperative organizations that connect industry, academic, governmental, private and community partners in a region. While the exact structure will vary between biospheres based on regional needs and local conditions, they are typically led by a local advisory group or steering committee that contributes to the logistical support function of biospheres. The steering committee coordinates activities and conducts public meetings between partners, which may include: businesses, agriculture, economic development entities, Native American tribes, nongovernmental organizations, universities, civic organizations, governmental agencies, and more. This cooperation across disciplines and sectors allows the regions to be laboratories of ideas for finding forward-thinking solutions to today's local and global challenges. In the United States, the twenty eight biosphere reserves operate primarily independently under the guidance of the United States Biosphere Network.

Every ten years, regions must submit a periodic review to the International Coordinating Council (ICC) of UNESCO to retain their designation. This review entails questions regarding the biosphere's fulfillment of the three main functions of a biosphere region: (1) conservation, (2) socio- and ecologically sustainable development, and (3) logistical support. In 2013, the U.S. Department of State approached the National Park Service to explore renewing the UNESCO recognition of 47 existing biosphere reserves in the U.S. Due to expanded requirements and their relative dormancy over several years, 19 sites sent letters of withdrawal to UNESCO. Twenty-eight subsequently submitted periodic reviews that were accepted. . As the United States Biosphere Network prepares for the next round of submissions, reconnecting the communities and partners of the network is paramount, providing guidance and capacity to individual regions to support as many biospheres through the process as possible. The SEAS capstone team was brought together with this goal.

Chapter 2: The SEAS Capstone Project

The intended impact of the SEAS collaboration with the United States Biosphere Network was to increase the capacity of the Network to support collaboration between biosphere regions, provide resources for successful periodic reviews, and demonstrate the value of the American biosphere regions' biodiversity conservation and sustainable social, economic, and environmental development practices. The key work of the project was divided into three teams with corresponding scopes and deliverables.

1. Biosphere Community Key Actor Inventory and Narrative Analysis

Interviewing key actors among the 28 biosphere regions to establish capacity and develop the value narrative of the US Biosphere Network;

Preparing resources to close partnership and development gaps for the Periodic Review process.

2. Increasing Research on the United States Biosphere Network

Compiling a report on the work of the United States biosphere regions regarding climate resiliency;

Measuring the gender inclusivity of the United States biosphere region and providing actionable recommendations.

3. ArcGIS Story Map and Geodatabase Reconstruction

Developing an ArcGIS story map connecting people and projects to biospheres to foster communication, collaboration, and transparency;

Creating a critical geodatabase that houses all the zoned shapefiles for each of the United States biosphere regions.

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Chapter 3: Qualitative

Abstract

Our investigation centered on assessing the current connectivity of the Biosphere Reserves and exploring opportunities for enhancing the efficacy of these connections, while also addressing the specific challenges faced by individual reserves. A fundamental principle of the project was conceptualizing the United States Biosphere Network (USBN) as a 'network of networks.' At present, the majority of Biosphere Reserves operate with varying levels of collaboration with local stakeholders and neighboring communities,with infrequent collaboration with the wider USBN. Semi-structured interviews were conducted with the aim of establishing a comprehensive framework to guide the development of activities within both the individual Biospheres and the USBN as a whole. The results of the interviews were combined with information gathered through participant observation and expert elucidation identify: (1) demonstrated operational within the Biosphere Regions that were barriers to meeting the standards outlined by the UNESCO MAB program; (2) collaboration gaps both within individual regions and among the wider Biosphere Network; (3) areas of best practice amongst the biosphere regions surveyed in addressing these identified needs and collaboration challenges. Ultimately this analysis resulted in the conclusion that while much of organizational capacity was relational to the size and level of social and geographic diversity within the bounds of a Biosphere Region, there were steps that could be taken in planning to increase productive collaboration and the fulfillment of the MAB mission. Additionally, we discovered that there was a misalignment between the perception and the reality of shared experiences and needs between Biosphere Regions throughout the network. We ultimately created three in-depth case studies that each highlight a best practice currently being implemented in one area of the network along with recommendations for wilder adoption.

Introduction and Background

Biosphere Reserves are internationally recognized areas of unique ecological and cultural heritage as recognized and designated by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Within these areas partners and communities work together to advance conservation and sustainable development by supporting positive relationships between people and place. The United States Biosphere Network (USBN) is made up of 28 unique recognized regions throughout the Contiguous United States, Alaska, Hawai'i and Puerto Rico. The United States was one of the countries that attended the 1968 "Biosphere" conference where the idea of an international organization of sites focusing on the merging of sustainable development and conservation first arose, and twelve of the currently active U.S. Biospheres were among the first cohort of thirty-two sites to receive the official Biosphere Reserve designation from UNESCO in 1976. The MAB Programme and its implementation within the U.S. have both undergone different iterations since inception

which have led to the current state of the network. Understanding this context was instrumental in ensuring that the final set of recommendations we created addressed the root causes of current issues and provided actionable steps that were relevant to all members of the network.

All UNESCO Biosphere Reserves require a core area of legally designated conservation that is important for and devoted to local biodiversity. Due to this legal component, many international Biosphere Reserves develop around national reserves, parks, and wilderness areas. The U.S. follows this pattern, and many of the current U.S. Biosphere Regions are based around, and even named after, pre-existing national or state parks. This, combined with the unbalanced focus on conservation actions in the initial years of the program, has created the perception that the Biosphere Region and the state or national park are one and the same. USBN leadership has identified this as a problem, as it is not only inaccurate, but also undercuts efforts to expand partnerships and activities in the managed use areas and areas of cooperation and partnership. Over-reliance on one model of conservation and leadership structure leads to a degree of inflexibility that prevents the continuation of Biosphere activities in the face of challenges like the recent staff and funding cuts within the U.S. Department of the Interior. While parks and protected areas have served and should continue to serve conservation roles in the MAB model, USBN leadership has been working to transition the organizational model of current Biosphere Regions away from a park-centric leadership model towards a community organization-based leadership model in order to create a network that is resilient to external sociopolitical pressures.

One of these pressures is the current state of the relationship between the United States and United Nations agencies like UNESCO. Functionally, the United States Biosphere Network operates structurally and operationally independent from its international counterparts. However, the often tenuous relationship between the U.S. government and UNESCO introduces a degree of instability regarding the program's long-term viability. The U.S. officially withdrew from UNESCO for the first time under the Reagan administration in 1983 and did not rejoin the organization until 2002 under George W. Bush. The Trump Administration withdrew from UNESCO in 2018. The U.S. again re-joined UNESCO under the Biden Administration five years later in 2023, and retains membership as of April 2025. The sporadic U.S. history of withdrawing from and reentering UNESCO repeatedly and failing to pay country dues has undermined the U.S.' ability to influence or participate in debates or programs under UNESCO. There are concerns that another withdrawal is upcoming, and this creates an uncertainty with collaborators throughout the network on the long term stability of the program within the U.S.

This uncertainty is further compounded by domestic political partisanship, wherein certain groups express skepticism toward UNESCO as a specialized agency of the United Nations. Unlike many international biosphere reserves, American biosphere programs do not receive direct federal funding under a budget line item. Rather any federal support comes through funding or technical assistance primarily from the National Park Service and more

recently international partners, and from the engagement of NPS sites within individual Biosphere Regions. With the exception of the Pinelands National Reserve in New Jersey, they also lack consistent financial support from their respective state governments. As a result, organizational capacity is provided by the local partner organizations within the sites. In contrast, the Mura-Drava-Danube (MDD) Biosphere Reserve, a transboundary initiative spanning five European countries, receives co-financing from the European Union, reflecting a more integrated and institutionally supported approach to biosphere reserve management.

Beyond the distrust of international working groups, there exists a schism internally between marginalized groups and governmental actors in the conservation space. The history of land management in the United States is deeply entangled with patterns of dispossession, particularly involving the creation of public lands. Across centuries, government agencies and powerful interests have repeatedly seized land from those with less institutional power, most notably Indigenous communities and other historically marginalized groups. As a result, contemporary conservation efforts, especially those that involve designating land as "protected" or establishing it as a government-managed reserve, are often met with skepticism or distrust. This legacy continues to shape how local communities engage with and perceive conservation initiatives, particularly when those efforts are perceived as top-down or exclusionary in nature.

Many of the public lands acting as core areas and areas of partnership and collaboration within Biosphere Regions carry with them complex and often painful histories of dispossession. These histories are not merely background. To this day they actively shape contemporary relationships between communities and conservation efforts, influencing how such initiatives are received and whether they are viewed as restorative or extractive. A notable example of a Biosphere Region addressing this history is Obtawaing in northern Michigan. The area that Obtawaing inhabits is marked by a legacy of forced removals and coercive treaties, but there are ongoing efforts to honor the land and its native inhabitants by including indigenous communities in the Region's leadership and as direct partners. Obtawaing (previously the University of Michigan Biological Station Reserve) was renamed in 2021 to reference the Anishinaabe village that was the halfway point or meeting place among a group of 20 coastal villages on the shores of Lake Michigan. Thus, the name both honors the centrality of an important indigenous place name in this region as well as the centrality of the role that the Biosphere plays in conversations around conservation, culture, identity, and cohesion.

The designation of Congaree National Park in 2003 was met with significant concern from local community members. The surrounding area holds one of the highest rates of Black land ownership in the United States, a result of land reparations provided by the state of South Carolina following the Civil War. For many residents, the prospect of a federally managed conservation area (park) raised fears that such a designation would remove land from black ownership and thus diminish local autonomy and disempower the community in shaping its developmental future. The area had received the Biosphere Reserve designation

in 1983, but due to the U.S. withdrawal from UNESCO went inactive almost immediately and was not reactivated until 2016.

Given the historical context surrounding land use and agency within the U.S., the USBN made the decision to intentionally use the term “Biosphere Region” rather than the more commonly used “Biosphere Reserve”. This linguistic shift reflects a conscious effort to move away from terminology that may carry connotations of exclusion or control, and instead emphasize inclusivity and regional identity. In order to recognize and respect this decision we are using the following naming conventions throughout this document. When referring to the MAB Programme as a whole, an international BR specifically, or U.S. BRs prior to the renaming from reserve to region, we will use the term “Biosphere Reserve.” When referring in present tense to the collective of U.S. based BRs or referring specifically to any U.S. based BR post renaming convention we will use the term “Biosphere Region.”

At its core, the biosphere region model aspires to present an alternative approach to conservation, one that moves beyond traditional frameworks rooted in restriction of access and the conceptual separation of people from nature. Rather than emphasizing exclusion, biosphere reserves are designed to foster coexistence, offering a model of land stewardship that supports the flourishing of both ecosystems and human communities. Building a network of knowledgeable local partners enables decision-making around economic development that prioritizes both community well-being and long-term ecological health. By drawing on localized expertise and lived experience, such networks help ensure that development strategies are contextually appropriate, sustainable, and aligned with the broader goals of the biosphere model.

As one interviewee from the Mojave–Colorado Biosphere Region stated:

> “*I sort of sometimes want to say to people, I like plants and I like flora and fauna, but I love families. You know, I think sometimes the park people forget about people. I don't want to call them tree huggers, but there's so much conserving or protecting nature that they don't even realize. This is what I took out of the first biosphere workshop I went to. People are just as much a part of an environment or a biosphere, yes, as anyone else; we are not removed from the environment. We're affecting it.*”

Methodology

Our team was approached to do an assessment of the Biosphere Network, and provide feedback and technical information to strengthen capacity. The Network had a group of twenty-eight siloed regions that they wanted to transition into an interconnected “network of networks” that was actively sharing resources and information.There were a few core questions that we were asked to delve into, as they had been identified by a previous study as key areas of concern within the Biosphere Network. (1) What is the value prospect of the

Biosphere as a Network? (2) What is the value of a Biosphere to its community? (3) How do we transition these insights into actionable next steps for the network?

We began with a review of the available twenty-eight periodic reviews, the UNESCO MAB technical guidelines and working documents; and a review of publicly available information on the Biosphere Regions from websites, social media, and news agencies. As connectivity both between and within regions was a key area of need identified by our advising team, we narrowed our focus in this review to identifying the breadth and diversity of partnerships currently active within Biosphere Regions, and the frequency of documented inter Region collaboration. In this initial review we used public facing communication as a stand in for the public awareness of the Biosphere Region and thus a potential indicator of the community narrative of their local Biosphere Region.

This initial review highlighted gaps across the network between the MAB goals and the activities being undertaken by Biosphere Regions. There was an overwhelming focus on conservation over sustainable development and logistical support in the periodic reviews as well as the public-facing communication. This aligned with a lack of organizational diversity in partnerships, with many Biosphere Regions listing governmental agencies (federal, state, and local) as the largest percentage of partnerships within their periodic reviews. There was also a significant lack of documented public engagement within the reviews and through public online platforms.

It became clear that there was a lack of understanding of the various perceptions and motivations at play among network actors. We determined that in order to identify and recommend strategies for progressing the activities of individual biospheres and the network as a whole we needed to integrate a qualitative facet to our review of the demonstrated needs and collaboration gaps across the network. In order to narrow down our current understanding of these gaps into a set of actionable recommendations we developed an exploratory sequential approach where the document review informed an initial pilot set of interviews, which then informed subsequent extended qualitative field research.

The Pilot Phase

In the pilot, five semi-structured interviews were conducted with influential actors within USBN leadership to identify and characterize the multiple understandings of both the value prospect of the network and to develop a cohesive engagement plan for identified groups of interest. To do this, we developed a set of interview questions intended to: (1) Identify key actors within the Biosphere network or local communities who are high priority for one one-on-one or focus group interviews. (2) Identify broadly areas of key partnership dynamics or lack thereof in order to inform the development of the follow-up research questions. (3) Identify broadly the current narrative around the value prospects of the Biosphere regions to local communities in order to inform the development of the follow-up research questions.

The interviews were conducted on a semi-formal basis with a high level of freedom given to the interviewee to determine the pace and order of the interview. Over the course of the interviews, some questions about visitor engagement were removed as they proved to be unnecessary, while the variety of interviewees necessitated adjusting some questions related to the interviewee's partner organization. The final pilot interview guide is included in the Appendix A.

Community was one of the most talked about topics among all of the interviews. The initial research questions were focused on partnerships, but throughout the interviews, it became clear that partnerships were a subset of a focus on community by all of the interviewees Each Biosphere Region has distinct partner opportunities, facing specific challenges across varied sectors (agricultural, governmental, academic, indigenous, local). All participants cited difficulties in engaging diverse groups, suggesting a need to investigate these differences further. Regarding the value prospect of the USBN, the prevailing theme was connecting individuals with their environment, highlighted by three interviewees. Other emerging themes included logistical support, social backing for stewardship, and financial aid facilitated by USBN's federal connections. The concept of "Network" emerged as a critical theme, with all interviewees emphasizing its importance for resource sharing and logistical support. Strengthening existing connections was acknowledged as a challenge tied to the Man and the Biosphere Programme's international network foundation. Key challenges identified were logistical support barriers and uninvolved groups, as well as historical relationships and political instability, mentioned by two interviewees.

Final Research Questions

The final set of interview questions was developed collaboratively among all qualitative team members using information gained from the preliminary interviews and with the purpose of uncovering answers to our research questions:

1. What is the awareness of/feelings about the Biosphere?
2. What is the need of the local community?
3. What can the Biosphere do to meet that need?
4. How does that transform into a mission statement for the Biosphere?

Our interview questions were developed using an abductive approach. An initial framework was established based on our research questions and theoretical insights, which was then further informed by the data collected. We focused our interview questions on collaboration needs and gaps, but also included experiential questions about relationships to place and the three core mission aspects identified from the results of our pilot interviews. We employed a semi-structured format with a topic guide consisting of seven core questions for community members, supplemented by guided follow-up questions.

Our initial structure began with experiential questions covering general familiarity with the MAB program and the local biosphere region before moving on to questions about

partnerships, aimed at elucidating the perceived and realized value of network connectivity and mapping activities in their region. We concluded with more abstract questions intended to provide insight into systems of value surrounding the local community and personal relationships with the environment.

Originally, we planned to create separate interview guides for biosphere staff, partners, and community members. However, input from our advisors and feedback gathered during the pilot interview process clarified the structural makeup of biosphere working groups, revealing no functional delineation between partners and those conducting biosphere region activities. As our advisor noted, "the work of the partners is the work of the biosphere." Consequently, we reworked our interview guide to streamline the format, providing all interviewees with the same community-focused questions, and included a set of addendum questions for partners. This approach allowed for data comparison across the broader pool and provided further insights into the nature of biosphere-partner working relationships. The final interview guide is included in Appendix B.

Interviews were conducted both in person and virtually as needed. The majority were one-on-one; however, a few organically became focus groups due to participant availability constraints. Informed consent was obtained prior to each interview, and the consent form and data confidentiality protocol are included in the appendices. Once consent was acquired, interviews were recorded except in two cases where privacy requirements prevented recording. These recordings were transcribed using the Otter AI tool, producing written transcripts.

Each researcher was responsible for de-identifying and cleaning transcriptions. As linguistic precision was outside our scope of interest, we chose to transcribe in an intelligent verbatim manner to increase transcript legibility. Following transcription and de-identification, transcripts were uploaded to shared files for collaborative analysis. Although files were shared, it was decided that each researcher would independently code and analyze their own transcripts to leverage familiarity with the participant and the region gained through field experience.

At the conclusion of the interview period, each researcher conducted an emergent theme analysis of their own dataset, identifying three emergent themes. Collaboratively, we developed five emergent themes for further reflection. The codebook was modified iteratively to reflect both our initial research questions and these emergent themes. The final codebook is included in Appendix C. Each researcher coded their own responses and reconvened with the final codes to conduct the overall analysis.

Findings

The qualitative research into collaboration gaps and the value narrative of the U.S. Biosphere Network highlighted several key findings. The USBN plays a critical role in harmonizing conservation with socioeconomic development across its diverse biosphere

regions. Major themes that emerged from the study included the importance of network building, with a focus on creating cohorts aligned by mission and organizational structure rather than geographical proximity. The study also distinguished between capacity (the current ability of biospheres and partners to perform their work at the current moment) and resiliency, (the ability of Biosphere Regions to overcome challenges and continue work into the future) while highlighting the interplay and friction among mission objectives. These themes collectively underscored the need for improved alignment and strategic focus across the network. However, through our research and analysis, we identified significant challenges to this alignment that require attention to ensure the Network's long-term sustainability and effectiveness. These challenges include fostering inter-region collaboration, building network-wide resilience, transitioning from park-centered models to community-driven approaches, and mitigating issues such as turnover, siloing, and knowledge loss. Addressing these interconnected issues is essential for strengthening the USBN's capacity to adapt to environmental and societal changes while maintaining its mission of sustainable development.

Other findings include a widespread lack of understanding regarding Biosphere Regions; many respondents, especially those not actively engaged with the Biosphere Regions but involved in the local community, were unaware of UNESCO's MAB program and their local Biosphere Region. Even those who worked within partner organizations were often unaware of the three goals of the Biosphere Program, the boundaries of their local Biosphere Region, or other partners therein. Evaluating the value prospect of Biosphere Regions, or the USBN as a whole, and attempting to build a brand awareness among the general populace fell outside the scope of our project. However, the lack of clarity as to Biosphere activities, networks, and goals by partner respondents co-occurred with statements

	Parent Code	Child code	# of respondents	# of references
1	Capacity	General	3	14
		Funding Availability	14	19
		Manpower	12	29
		Time	9	14
2	Challenges	General	31	145
		Tribal Engagement	8	25
		Uninvolved Groups	16	24
3	Community	General	9	28
		Acceptance	14	48
		Awareness	19	76
4	Core Mission	General	12	121
		Community Building	19	101
		Conservation	16	50
		Core Conflict	13	37
		Sustainable Development	15	47
5	Network	General	9	42
		Building	15	42
		Communication	11	14
		Value of a Network	18	58
6	Stability	General	9	17
		Funding Longevity	7	7
		Knowledge Loss	5	5
		Turnover	4	6
7	Value	General	24	68
		Biosphere to Community	18	71
		Community to Biosphere	14	45

Aggregate response codes from the 32 interviews conducted across 8 Biosphere Regions by 4 interviewers

of concern about the value of the Biosphere Region, and lack of inner-group collaborative action. Key Actor groups were identified along with related opportunities and challenges for collaboration, this table can be found in Appendix D.

Figure 2: Aggregated responses for qualitative interviews broken down by parent and children codes

Themes Overview:

The initial findings from the table of code frequency across over 30 interviews in eight biosphere regions reveal a complex landscape of challenges and opportunities centered around stability, capacity, community engagement, core mission, value, network development, and regional challenges. These themes were present in all of our interviews in various ways that though are nuanced for their respected context, provide in depth knowledge on key gaps that exist between the core tenants of the MAB program and what is being enacted on the ground.

Resiliency emerges as a common but critical issue. This is encompassed by concerns about the longevity of funding, staff turnover, and knowledge loss. Many regions struggle with securing long-term financial support necessary for sustained growth and operational stability, often facing the risk of losing valuable knowledge as personnel change or depart. Political and economic uncertainty can play into the ability to secure additional funding through grants and philanthropy which has a tremendous impact on other aspects that enable BRs to be sustainable in the long-run.

Capacity constraints are evident in both financial and human resources. Operational funding remains a key concern, impacting planning, conservation activities, and partnership development. Additionally, the availability of manpower (biosphere staff and volunteers) is vital for implementing programs and maintaining regional activities, yet often falls short of regional needs.

Community acceptance and awareness are fundamental themes, with regions noting varying levels of local engagement and understanding of the biosphere's role. Acceptance of biosphere initiatives by local communities influences their willingness to participate and support conservation and sustainable development efforts. Raising awareness and fostering community buy-in are thus essential for regional success.

Core mission elements such as conservation, sustainable development, and community building are central tenants of the biosphere program. However, conflicts within zonation and program requirements sometimes hinder effective implementation. Balancing conservation priorities with socio-economic development remains a delicate challenge, requiring nuanced approaches that respect local contexts.

Value perceptions underscore the importance of mutual benefits between communities and biosphere regions. Communities often value the biosphere for its technical expertise and knowledge, while biospheres see value in community contributions, such as local knowledge and skills. Recognizing and enhancing these reciprocal relationships can strengthen regional partnerships.

Network development plays a strategic role, with regions exploring how to leverage the network framework for growth and information sharing. Effective communication within the network is crucial for building capacity, sharing best practices, and fostering collaborative initiatives. These findings further substantiated the importance and value proposition of USBN has on the U.S. BRs holistically.

Finally, regional challenges include the presence of uninvolved groups, limited tribal engagement, and region-specific issues such as environmental catastrophes. Addressing these obstacles requires targeted strategies to involve marginalized groups, incorporate indigenous perspectives, and respond to unique regional threats.

Actionable Themes Overview:

Based on the initial findings outlined above, we identified three key themes that are not only prevalent across the broader biosphere region network but also present clear opportunities for growth through actionable steps: (1) the collaborative opportunities of characterizing Bisophere Regions along social and organizational spectrums, (2) the differences between capacity and resiliency and how each is influenced by external and internal factors, and (3) areas of repeated disconnect that arise in the pursuit of the three MAB missions within Biospheres. These insights form the foundation of our case studies, which showcase successful strategies currently being implemented within the USBN. By highlighting these examples, we aim to provide practical guidance for addressing similar challenges in other biosphere regions.

Discussion and Recommendations

Theme 1: Network Building

Background of Network Cohort Building

To identify opportunities for increased collaboration and implementation of our recommendations, we sorted each of the eight Bisophere Regions included in the qualitative review along two axis. After deliberation amongst the research team, it was determined that the three themes of capacity vs. stability, core mission friction, and network building and related recommendations tie back to organizational structure and diversity of regional needs.

We oriented the y-axis as a spectrum from heterogeneous to homogeneous social and geographical make-up as a representation of the diversity of needs and perspectives under the

purview of the region in question. The social and geographic make-up was determined through an amalgamation of information provided by the regions in question 1.m, question 3 and question 7.2 of the periodic review document. This was then compared to information on the Biosphere Region's communities and needs provided by interview respondents, and the knowledge of the region gained by the researchers through participant observation.

We then plotted the study Biosphere Regions along an x-axis from diffuse to consolidated leadership structures. This definition relied more on the understanding of the structural makeup of the Biosphere Region gained by the researcher through the research period, compared to the responses of interviewees to the initial partnership and organization questions within their interviews. There was consideration to include the information provided by the individual regions in question 7.2, "What is the overall framework for governance in the area of the biosphere reserve? Identify the main components and their contributions to the biosphere reserve", of the periodic reviews. After deliberation, however, it was decided to not include the information from that question as there was a lack of consensus between the information gathered through interviews and the listed organization within the periodic reviews. We hypothesized that the differences were due to both the time elapsed since the most recent round of periodic reviews, as well as a combination of variability in the periodic review process and a lack of hierarchy inherent in a list of partners. If this process is implemented to map the wider USBN on this index, we recommend further research into the process of filling out the governance framework section of the periodic review.

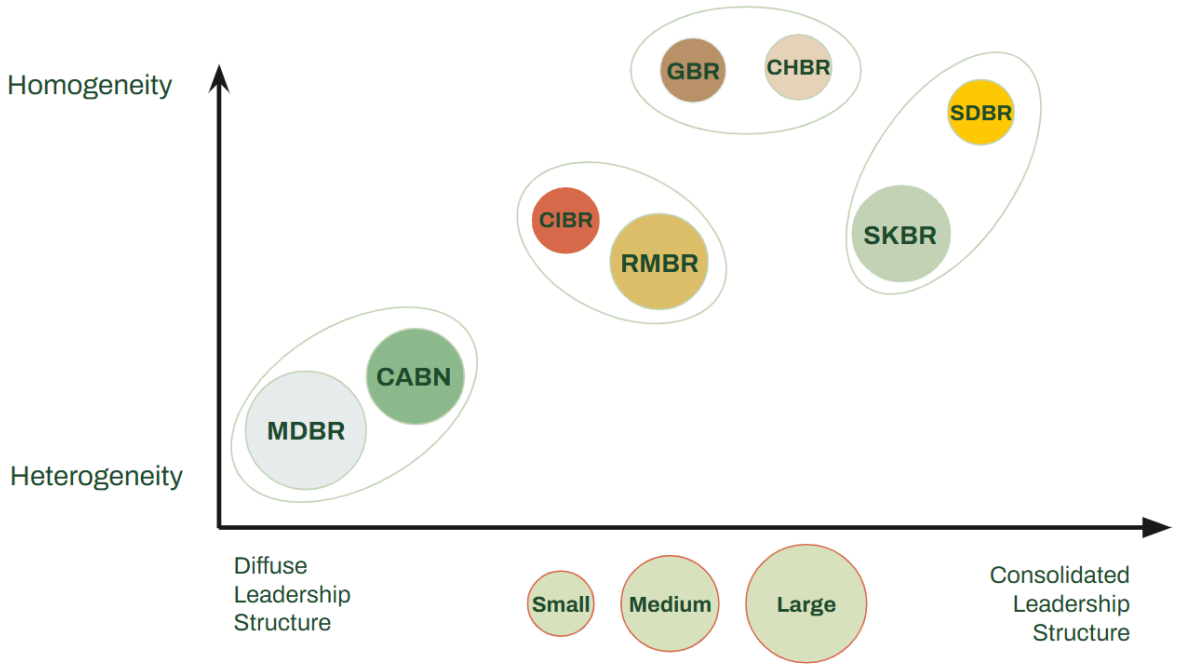


Fig. 3 Matrix showing the eight Biosphere Regions included in the qualitative review organized along axes of social and geographical heterogeneity and leadership structure.

After placing all eight Biosphere Regions included in the study on this matrix some patterns emerged. All of the Biosphere Regions included shared similarities in organizational and social make-up with Biosphere Regions in distinctly different geographies with different ecosystem types. This runs counter to the prevailing method of grouping Biosphere Regions according to ecosystem type, ie. coastal, mountain, desert, etc. Approaching Biosphere working groups through alignment in regional diversity and leadership structure provides an opportunity for increased inter-region collaboration and knowledge sharing based on overlapping challenges and needs.

This case study examines a collaborative initiative supported by Henkel AG & Co. KGaA and the German Commission for UNESCO. The initiative focused on building skills and fostering collaboration among three geographically distant Biosphere Regions, emphasizing cohort building based on shared missions and projects over proximity-based groupings. The case highlights how such collaboration can enhance connectivity, address local challenges effectively, and strengthen the overall network.

Project Framework and Objectives

The U.S. Biosphere Network was chosen as one of five national networks of UNESCO Designated Sites to receive funding from Henkel AG & Co. KGaA and the Fritz Henkel Stiftung in order to undertake a project building future skills within UNESCO designated sites. With the funding allocated, the USBN developed the “Sustainable Food and Environmental Education Pilot Program: Healthy Food, Healthy People, Healthy Environment.” The overarching goal of this pilot program was to cultivate sustainable agricultural and educational practices aligned with indigenous traditions across multiple biosphere reserves within the United States and its territories. The project framework allowed for an application from a UNESCO Designated Site or a consortium of UNESCO Designated Sites. Together with the German Commission for UNESCO, the USBN decided to select three biosphere reserves form its nationwide network through an open call in the USA and to apply for funding as a consortium in an effort to both represent the diversity of perspectives within our network as well as provide an opportunity for increased inter-reserve collaboration. This report encapsulates the multifaceted implementation journey, detailing each site’s initiatives, challenges faced, and the strategic adjustments made to meet goals.

After a brief proposal period, three of our Biosphere Reserves were chosen to develop a three month pilot program: Southern Appalachian, Guánica Forest, and Champlain-Adirondack. Throughout the process, the three sites were regularly brought together to discuss progress, challenges, and insights in collaborative working sessions. Within the sessions, the project leaders from each of the sites were able to gain insights from one another as well as receive support from a USBN designated project manager and two members of the USBN leadership team. Each site embarked on distinct, yet complementary,

initiatives focused on integrating indigenous knowledge with modern agricultural practices through community engagement and educational outreach.

Cohort Projects

Southern Appalachian Biosphere Reserve: “Agricultural Sustainability in Appalachia, Where Modern Science Meets Indigenous Tradition”

The Noquisi Initiative focused on coordinating educational programs to integrate modern science with indigenous practices for sustainable agriculture. At the culmination of their project, they orchestrated a workshop that combined local insights and expert presentations on topics such as plant intelligence and biodynamic farming. Set on Cherokee trust land, the event intended to create a bridge between traditional Cherokee agricultural practices and modern techniques. The primary challenge the Noquisi Initiative faced was logistical—scheduling around holiday periods and navigating weather-related disruptions caused by Hurricane Helene.

To overcome these challenges, the team exercised flexibility in event planning and demonstrated resilience in communication strategies. In the end, the workshop culminated in a transformative experience for participants, introducing them to novel agricultural concepts integrated with traditional wisdom.

Guánica Forest Biosphere Reserve: “Nurturing Our Island's Future: A Puerto Rican Sustainability Initiative”

The team in Guánica faced initial logistical challenges, including resource limitations and post-earthquake recovery efforts. However, these were mitigated by community initiatives to repurpose an abandoned school into a hub for learning and emergency response. The partner Protectores de Cuencas, in collaboration with the Puerto Rican Department of Natural and Environmental Resources, successfully launched a community nursery and sustainable agriculture initiative. PDC procured materials and established a nursery with a potting station and a diverse array of local plants with medicinal and nutritional uses. PDC developed educational materials, including a handout, presentation, and guide and within two months conducted workshops for 10 participants, combining practical and theoretical instruction.

The main success derived from deeply involving community members in all stages, ensuring that the project met its social and educational objectives. Contributions from skills-based volunteers such as an agronomist from the Las Arenas community were pivotal in providing expert agricultural guidance.

Champlain-Adirondack Biosphere Reserve: “Abenaki Food Traditions of Vermont: Educator Toolkit”

The South Hero Land Trust engaged stakeholders—teachers and historians—through workshops to cultivate a beta toolkit linking Abenaki culture with the broader educational

curricula. South Hero Land Trust engaged tribal leaders from the Abenaki Nations of Odanak and W8linak to learn about existing programs and initiatives. They also hosted a workshop with teachers and historians, which informed the creation of an educational toolkit focusing on traditional Indigenous agricultural and food practices that meets Vermont educational standards. Small groups designed curriculum aspects, collaborating with Odanak on media and resources. A draft of the curriculum is currently being beta-tested by teachers.

Collaboration with the Abenaki tribes presented an imperative to respect tribal sovereignty and cultural identities, which required additional adjustments to curriculum development timelinesThe project faced scheduling conflicts and procedural learnings in navigating tribal protocols. Ongoing iterations of the educational toolkit involved Abenaki feedback to ensure cultural authenticity, while the necessary flexibility in timelines facilitated meaningful participation.

Outcome and Future Directions

Across all sites, the project fortified community ties and catalyzed sustainable agricultural practices. By merging traditional knowledge with modern practices, these initiatives laid the groundwork for continued education and cultural preservation through an innovative blending of traditional and modern knowledge. The project underscored the effectiveness of cultural collaborations, resulting in innovative solutions and enriched community empowerment. Interdisciplinary approaches proved beneficial, aligning educational themes with diverse expertise, while community involvement ensured relevance and ownership. Unanticipated challenges emphasized adaptability in planning and execution.

In conclusion, the creation of a diverse cohort under the shared project “Building Future Skills in UNESCO Designated Sites” not only achieved immediate sustainable agricultural goals within each of the three U.S. regions included in Phase 1, but also laid a robust foundation for future education and cultural exchange initiatives within the US Biosphere Network and internationally. These endeavors exemplify how collaborative, culturally aware methodologies can lead to meaningful, long-lasting impacts across diverse communities.

Recommendations:

Align Regions by Diversity and Leadership Structure:

- Action: Implement a network framework that groups Biosphere Regions based on their socio-geographic diversity and leadership structures rather than ecosystem type.
- Benefit: This can foster inter-region collaboration and knowledge-sharing based on shared challenges and administrative structures.

Enhanced Governance Framework Reporting:

- Action: Encourage detailed and up-to-date inputs on governance structures during periodic reviews, ensuring consistent and reliable data collection.

- Benefit: Ensures a clear understanding of governance frameworks, which can aid in identifying complementary regions for collaboration, thereby minimizing core mission friction.

Leverage Cohort Building:

- Action: Promote cohort building through USBN leadership convening regions engaged in similar projects which are geographically distant yet socially and organizationally similar as determined by the groupings of Regions along the diversity/leadership matrix.
- Benefit: Enhances skill-building and connectivity across regions, as seen in the collaboration supported by the Henkel initiative.

Support Cross-Regional Projects:

- Action: Facilitate projects that integrate both traditional and modern practices, similar to the "Healthy Food, Healthy People, Healthy Environment" program.
- Benefit: Promotes sustainable practices and cultural preservation, as well as educational outreach across multiple regions.

Theme 2: Capacity and Resiliency

Capacity and resilience emerged as critical, interconnected themes shaping the effectiveness and sustainability of Biosphere Regions across the network. Our analysis revealed that limited capacity defined by available manpower, stable funding, and institutional knowledge consistency constraints what Biosphere Regions are able to achieve. Most Biosphere Regions operate without dedicated staff, instead relying heavily on partners and volunteers to carry out core functions. This reliance creates vulnerabilities: when volunteer energy wanes or when key partners move on, essential work can stall or disappear altogether. The lack of stable, full-time staffing makes it difficult to maintain momentum, build long-term relationships, and pursue ambitious projects.

Funding is another persistent challenge for capacity. Operational funds are often sporadic, unpredictable, and not accessible to all Biosphere Region equally. This uncertainty makes it hard to plan for the future, invest in new initiatives, or retain talent. The result is a cycle where energy is spent seeking short-term grants or rebuilding after funding gaps, rather than advancing long-term goals. Political regime changes and shifting priorities at the federal or state level further exacerbate this instability, as support for UNESCO designations and conservation programs can fluctuate dramatically from year to year.

Resilience, meanwhile, is undermined by high turnover and knowledge loss. Non-profit and academic partners, who often serve as the backbone of Biosphere Region activities, experience frequent turnover. Many Biosphere regions depend on a "singular champion" model, where the departure of one key individual can mean the loss of institutional memory and a need to start over. There is no central repository for information

or best practices, so each transition risks erasing hard-won lessons and forcing new teams to reconstruct what came before. This constant rebuilding diverts energy from forward progress and makes it difficult for BRs to respond nimbly to ecological upheaval or new opportunities.

Finally, the oversaturation of working groups and the lack of clear differentiation in BR activities can dilute both capacity and resilience. With many groups working in similar spaces, it is not always clear what unique value the Biosphere Region brings, leading to little oversight, limited support, and missed opportunities for impact. In sum, strengthening both capacity and resilience will require not only more stable resources and staffing, but also intentional strategies for knowledge retention, role clarity, and adaptive partnership.

Resilience, meanwhile, is undermined by several factors that are closely tied to capacity limitations. High turnover among non-profit and academic partners is a persistent challenge, especially in reserves that rely on a "singular champion" model where one or two individuals are responsible for most of the work. When these key people leave, the reserve often loses critical institutional memory and momentum, forcing teams to start over and spend valuable energy on reconstruction rather than on forward progress.

Knowledge loss is a recurring issue, as there is no central repository for information or best practices. This means that each transition risks erasing hard-won lessons and forcing new teams to reconstruct what came before, rather than building on previous work. The lack of stable knowledge management not only slows progress but also makes it difficult for BRs to respond nimbly to new opportunities or ecological upheaval.

External disruptions further threaten resilience. Political regime changes and shifting priorities at the federal or state level make it hard to plan around insecure funding and support, especially for the UNESCO designation. Ecological upheaval, such as climate-driven disruptions, adds another layer of unpredictability, requiring adaptive responses that many reserves are not equipped to deliver due to limited capacity

CABN: A Case Study in Resilience and Capacity

This case study examines the distinct ways CABN navigates the balance between building capacity for conservation efforts and fostering resiliency in the face of environmental and organizational challenges, as well as the closely related nature of the two concepts.

Throughout the SEAS USBN project's work in biosphere regions across the U.S. during the summer of 2024, organizational challenges frequently centered around issues of capacity, stability, or both. In particular, biosphere reserves in the United States have long navigated shifting political dynamics. These challenges were exemplified in the most recent periodic reviews, which resulted in the loss of nearly half of the country's designated biosphere reserves. Additionally, the broader instability of U.S. engagement with UNESCO

has contributed to uncertainty; the nation withdrew from the organization in 2016 under the Trump administration, only to rejoin five years later (US Withdrawal).

The continued instability surrounding conservation and land management organizations in the United States, coupled with disruptions to previously available funding streams, presents an existential challenge to many partnership organizations that biosphere reserves rely on as a core component of their work. Moreover, the ongoing uncertainty includes the very real possibility of the U.S. withdrawing from UNESCO once again, further complicating long-term planning and collaboration efforts.

CABN stands out as one of the most active and well-connected biosphere reserves in the United States, supported by a robust leadership team and a highly engaged steering committee. Comprised of influential community leaders from New York and Vermont, the committee fosters long-standing partnerships that naturally emerge from their extensive local involvement. CABN maintains strong affiliations with multiple higher education institutions, including the University of Vermont and Paul Smith's College, as well as with local NGOs dedicated to resource management and community development. A key aspect of their approach is maintaining a visible and active presence within the community, exemplified by initiatives such as the "Biosphere in Your Backyard" program (Biosphere in Your Backyard).

Despite its strong partnerships and leadership, CABN continues to face significant challenges related to capacity and resilience, reflecting broader trends observed in other biosphere reserves. This case study aims to analyze and categorize these challenges to provide greater clarity in addressing them.

Defining Capacity versus Resilience

While both capacity and resilience relate to the biosphere's ability to sustain its core functions, they are distinct yet complementary concepts. Capacity refers to the ability or potential of a system to perform functions or absorb inputs—essentially asking, "How much can this system handle?" Resilience, meanwhile, describes how well a system can recover from and adapt to disturbances or change. In practice, issues of capacity are often more difficult to address in case studies, as they involve long-term structural concerns such as funding, staffing, and resource availability. Resilience, on the other hand, can often be enhanced through organizational partnerships, adaptive management, or structural reorganization. As ecological and political upheaval intensify, resilience will become an increasingly critical quality for systems striving to endure and thrive.

Issues Related to Capacity

1. **"The Work of the Biosphere is the Work of the Partners"**

At present, much of the biosphere's work is carried out through its many partner organizations. As a result, CABN's capacity is inherently tied to the capacity of its partners. One of the central sets of questions we explored in our interviews focused on the interplay between CABN and these partners—how they influence, inform, and strengthen one another.

The most common response was that the biosphere designation lent partners a sense of credibility: a recognized name in land conservation efforts that leaders could point to when seeking support or legitimacy. However, several active members noted that the relationship between the USBN and its partnerships could sometimes feel lopsided:

> *"Again, I don't know that [Local partner NGO] needs us as much as we need them. They're doing great work around youth climate action [...] Yeah. So, if CABN went away tomorrow, it's not going to change their lives all that much. But if [The University of Vermont] or Paul Smith [College] were gone tomorrow, or [Other partner NGO], that would change CABN a lot. Definitely. I think we're at a stage where we're getting more value than they are, having their folks at the table and their visions and their ideas of bio-regionalism."*

As mentioned in the quote, CABN, like many other biosphere regions, is closely associated with academic institutions, in this case, multiple universities. In several interviews, we found that academics involved in community partnerships often first learned about CABN through a central figure, and were surprised they hadn't heard of it sooner, especially given how closely its mission aligned with the goals they had been promoting in their own work. Many described the biosphere as a natural fit. Each of the professors we interviewed at the University of Vermont emphasized the significance of bioregionalism—a philosophy that encourages people to root their lives, economies, and governance structures in the ecological realities of their region, beyond constructed political borders. They saw this concept as central to their teaching and one of the most valuable ideas to emerge from the biosphere model.

CABN's partnership with the University of Vermont and Paul Smith's College offers a unique example of collaboration. Faculty members from both institutions, who were also part of the biosphere's steering committee, co-developed and co-taught a course on bioregionalism, with a focus on biosphere reserves. The course introduced many students, particularly those from Vermont, to the concept of biospheres, and some expressed interest in engaging more deeply with CABN after the class concluded (Darr).

One of the most biosphere-oriented partnership programs has emerged through CABN's collaboration with The Wild Center in Tupper Lake, New York. For several years, The Wild Center has hosted a Youth Climate Summit, bringing together young people from across the Champlain-Adirondack region to share strategies for organizing and to showcase the diverse environmental work happening in schools and youth-centered spaces (Youth Climate Program). This past summer, the summit expanded in scope by welcoming young participants from the Frontenac Arch Biosphere in Ontario, Canada, for a cross-border exchange with their CABN counterparts (Youth Climate Action). This example of transnational biosphere collaboration—especially one centered on youth—demonstrates the power of building resilience through diverse, and when possible, international networks. The

relationships forged during these events have the potential to outlast political or environmental upheaval, sustaining a sense of shared purpose and regional stewardship into the future.

2. Manpower & Funding

The two most commonly cited challenges in our interviews with CABN stakeholders were deeply intertwined: a lack of time and personnel to fully carry out the mission of the biosphere and to effectively communicate its goals across the broader Champlain-Adirondack region, and insufficient funding or connections to adequately support partnership organizations. During our visit, we found that only one person deeply involved with CABN held a formal role within the U.S. Biosphere Network, and even that was a part-time appointment. Most of the people contributing to CABN's work serve on the steering committee or are engaged through partner organizations. They are highly committed community members, but they are also stretched thin, balancing biosphere efforts with other responsibilities.

When speaking with partners, one of the most commonly mentioned potential benefits of being associated with the USBN was improved access to grant opportunities and other financial resources. This was often framed as a result of being affiliated with a stable and recognizable organization, which could lend credibility to funding proposals or help partners become aware of more niche, international funding streams. However, while this benefit was brought up multiple times, none of the partners we interviewed had directly experienced it. Instead, it existed as a theoretical advantage—a benefit that made sense in principle but had yet to be realized in their work. Given that this challenge is common across biosphere reserves nationwide—and, in fact, a persistent concern for most small-scale environmental nonprofits—one of the most tangible contributions the USBN could make would be to establish a centralized platform to help its constituents identify stable funding sources.

Issues Related to Resiliency

1. Regime Changes & Social Divides

An important aspect of CABN's political geography is the stark division along state and political lines. In the majority of interviews conducted with Vermont-based partners, respondents noted skepticism from counterparts in New York, particularly regarding UNESCO as an institution. This skepticism led some to oppose CABN's formation altogether. One interviewee described the recurring cycles of political upheaval in the U.S. as "pendulous," oscillating between isolationism and collaboration. Another interviewee noted the impact that this political division had on the momentum of CABN as a program:

> *"...we stepped in as appropriate, stepped in a little bit after the fact to re-energize some of the initial work that was done because it was so politicized. Even the basic program felt like it was being attacked politically as this 'regulatory body'. And so it's only been–in my sense, in the last 15*

years that a lot of that energy has dissipated. The [program run by interviewee] and CABN have had the only opportunity to start to thrive in the last five or seven years."

While it may be unrealistic to expect CABN to serve as a unifying force in today's increasingly polarized political climate, our interviews revealed a different, yet equally significant, divide emerging within the region. Repeatedly, community members emphasized a growing disconnect between the needs and voices of long-time residents and those of the tourist population. A recurring point of frustration centered on the perception that natural resource management practices were increasingly geared toward enhancing the tourist experience, rather than prioritizing the long-term sustainability of those resources for local use and access. This sentiment underscores a critical challenge for CABN: balancing the economic benefits of tourism with the ecological and cultural needs of the resident community. This tension highlights the underlying friction between the mission points of sustainable development and conservation—who are these resources being managed for, and to what end?

2. Ecological Upheaval

In our time on the ground performing interviews, the region was experiencing enormously heavy rain and hurricane warnings, leading to the cancellation of many events and the eventual destruction of infrastructure. The flooding in the region, which coincided with our time on the ground conducting interviews, underscored the profound intersection between social and ecological dynamics. The area was grappling with torrential rain and hurricane warnings, which disrupted daily life, led to the cancellation of numerous community events, and ultimately resulted in the destruction of key infrastructure. Our visit, which aligned with the one-year anniversary of the devastating flash floods of July 2023, highlighted the ongoing vulnerability of the region to such catastrophic events. The floods a year prior caused 11 fatalities and an estimated 2.2 billion dollars worth of damage (US Department of Commerce).

It is crucial to institutionalize adaptive management practices that allow biosphere reserves to remain flexible and responsive to shifting ecological and social conditions. This could involve conducting regular resilience reviews to assess how well regions like CABN are adapting to environmental changes, alongside implementing adaptive planning tools that can adjust as new data emerges. Additionally, scenario planning exercises would help reserves prepare for various potential future challenges, ensuring they are equipped to handle uncertainties in both ecological and political landscapes.

3. Turnover & Knowledge Loss

As outlined in previous sections, CABN and USBN function without full-time staff and instead lean on partnerships, especially with academic institutions. While these collaborations bring valuable energy and ideas, they tend to be short-lived, since student involvement (including our own) is typically limited by academic timelines. The instability

of political systems compounds this challenge, as individuals working in government-supported roles, or in positions tied to public funding, may be forced to shift focus—or disappear altogether—when political tides shift.

There needs to be some sort of formalized process of ensuring that access to student-developed technology and research is accessible and utilizable by biosphere partners after the students have departed their home institutions. To address institutional knowledge loss due to turnover, particularly from student researchers and time-limited collaborators, the USBN could prioritize the development of a centralized, strategic knowledge management system. This platform would serve as a living repository of resources, including project documentation, partnership frameworks, engagement strategies, funding opportunities, and evaluation tools. By supporting continuity across regions and reducing duplication of effort, such a system would significantly enhance organizational resilience. Initiatives like the Biosphere Bites webinar series demonstrate the appetite and potential for structured, cross-regional learning (USBN Launches). To further this, intentional coordination between youth boards (both system-wide and site-specific) and steering committees should be formalized to ensure ongoing alignment, visibility, and institutional memory.

Key Takeaways and Recommendations

1. Strategic Visibility and Narrative Building

a. Develop a compelling, shared narrative of CABN's mission that speaks directly to multiple stakeholder groups—residents, tourists, educators, and policymakers—highlighting the biosphere's unique value and local relevance.
b. Use bioregionalism as a framing device to make the mission legible and resonant across political or cultural divides.
c. Regularly update and publicize success stories and project outcomes through local media, events, and partner newsletters to maintain visibility and reinforce CABN's relevance.

2. Institutional Anchoring and Role Designation

a. Formalize and expand on partnerships with core institutions like UVM and Paul Smith's that can buffer against turnover and funding gaps.
b. Identify and compensate at least one full-time regional coordinator or community liaison to manage communications, capacity-building, and strategic continuity across projects.
c. Institute a leadership pipeline: Develop a mentorship or succession planning model that prepares future leaders from both academic and local communities to take on roles of increasing responsibility within CABN, ensuring a steady flow of experienced individuals to maintain project momentum.

3. Climate Adaptation through Local Knowledge

a. Partner with local municipalities and emergency response organizations to co-develop community-specific climate adaptation strategies grounded in CABN's ecological data.
b. Use participatory mapping and storytelling tools to document and share how climate events are impacting livelihoods and ecosystems in both New York and Vermont regions.

4. Centralized Knowledge Management and Resource Sharing

a. Establish a centralized knowledge repository to ensure that all project documentation, research, partnership frameworks, and funding opportunities are stored and easily accessible to biosphere partners. This repository would reduce duplication of efforts and streamline project planning across regions.
b. Implement formal mechanisms for ensuring that knowledge and key learnings from student researchers, collaborators, and project participants are captured and made available to future biosphere partners. This could include standardized reporting templates or knowledge-sharing platforms that allow for smoother transitions when personnel changes occur.

Theme 3: Mission Friction

This case study focuses on highlighting the novel methods and approaches Cascade Head Biosphere Region (CHBR) has developed and implemented to overcome the friction between engaging the community and being stewards of the environment.

Mission friction within Biosphere Regions has been emerging where there is a disconnect between the three missions of the MAB Programme, sustainable development, conservation, and community engagement. Our respondents repeatedly highlighted the challenge of balancing ecological sustainability with the socioeconomic development priorities, values, and needs of local communities. While conservation partners work to protect biodiversity and ecosystem services, local communities may prioritize economic livelihoods, cultural traditions, or immediate needs, especially when conservation efforts are perceived as limiting access to resources or economic opportunities. This misalignment can lead to resistance, disengagement, or skepticism toward biosphere initiatives.

A significant aspect of mission friction involves the struggle to achieve genuine, broad-based community participation. Marginalized groups, including indigenous peoples or those connected to traditional industries, have historically been underrepresented in decision-making processes. Failing to address and correct for this history can reinforce perceptions of exclusion from public land that further entrench resistance to conservation goals. This gap in representation was identified though the interview process, and over half of our respondents when asked what groups the Region should be involving more, named a minority group, and 72% named a community based organization, or public service office. However, the review of information from the most recent set of Periodic Reviews showed

that in terms of regional Biosphere leadership and partner networks, stakeholders were overwhelmingly caucasian and representatives of conservation focused organizations, and did not align with the level of diversity present in the local community as determined though census track data. This raised concerns that the work of some Biosphere Regions did not reflect the full diversity of community interests.

Resource and capacity constraints further exacerbate mission friction. Many biosphere initiatives operate with limited funding and rely heavily on volunteer labor, which can lead to burnout, instability, and a reduced ability to sustain long-term engagement. Skills gaps in project management and technical expertise also limit the implementation of inclusive and adaptive strategies. Compounding these challenges are gaps in communication and awareness; many community members remain unaware of the biosphere designation or misunderstand its implications, resulting in apathy or suspicion. Effective communication and ongoing dialogue are therefore essential for building trust and fostering shared understanding.

Another layer of complexity arises from the diversity of perspectives within communities themselves. Disagreements over goals, strategies, and resource allocation can be common, and if not managed constructively, can fragment initiatives and undermine progress. Transparent decision-making and conflict resolution mechanisms are critical to maintaining cohesion and advancing shared objectives.

Systemic and structural barriers, such as broader economic pressures, policy shifts, and regulatory constraints, can also impede the alignment of conservation and community development goals. These external factors often limit the flexibility of biosphere regions to adapt their approaches and scale up successful initiatives.

Addressing mission friction requires intentional, inclusive, and adaptive strategies. Proactively seeking input from all segments of the community, especially those historically marginalized, and adapting approaches based on feedback can help align conservation efforts with local priorities. Investing in local capacity, developing transparent and culturally sensitive communication, and establishing collaborative governance frameworks are all essential steps. By bridging the gap between conservation initiatives and community realities, biosphere networks can strengthen their long-term sustainability and effectiveness, thus working towards meeting both environmental and societal needs.

Problem Identification:

The tension between communities and environmental conservation efforts often arises from conflicting priorities and perspectives regarding land use and resource management. Key challenges typically include: (1) balancing community well-being with ecological sustainability, (2) addressing socioeconomic obstacles to conservation participation, particularly through the lens of Maslow's Hierarchy of Needs, and (3) overcoming a history of exclusionary practices that have marginalized minority groups and impacted their relationship with the broader community. On one side, conservation initiatives aim to protect

biodiversity, ecosystem services, and cultural heritage through sustainable practices. On the other hand, local communities may prioritize economic livelihoods such as meeting basic needs, focusing on community prosperity, or bridging the gap between historically excluded minority groups and the major community.

Traditionally, two contrasting approaches have been used to build consensus within communities regarding appropriate land use and the conservation needs of the natural environment. One is a strict ecosystem protection, what we are referring to as the “Reserve Model”, that enforces protection through exclusionary policies that often alienates local groups by restricting access to vital economic, environmental, and cultural resources. The other option is a “Community-Based Model” where conservation and sustainable development activities originate from the community itself. In contrast, the latter emphasizes participatory dialogue and collaboration but can face challenges when community aspirations do not align with predetermined conservation objectives or when resource constraints limit the implementation of inclusive strategies.

From our case study on CHBR, they adopted a community-based approach that exemplifies the core mission of UNESCO’s Man and the Biosphere (MAB) Program, which seeks to reignite engagement between the community and environmental conservation by fostering harmonious coexistence between people and nature . Situated in Lincoln City, CHBR operates within a relatively homogeneous community characterized by a population largely composed of retirees, upper-middle-class residents, and seasonal tourists. Historically, the area was home to the Siletz Confederation of over 30 tribal groups who maintained a reservation until the 1870s when the reservation was opened to non-Indian settlers . Consequently, the current demographic is predominantly white, with limited engagement from Native American communities.

Lincoln City’s demographic context provides CHBR with a unique advantage compared to other Biosphere Regions that must navigate the complexities of building consensus among diverse and often competing stakeholder groups. In contrast, Lincoln City’s relatively uniform socioeconomic makeup allows CHBR to focus more directly on its conservation efforts without the added challenges of reconciling multiple perspectives and priorities. Despite Lincoln City exhibiting the reminiscence of a decades old logging industry, a vast majority of the existing community can be categorized as retirees, upper middle class, or eco-tourists which in turn eliminates the dependency on natural resource extraction as a form of economic development.

By acknowledging this context, CHBR has been successful in championing the promotion of the Lincoln Community through activities and actions directly linked to the Biosphere Region itself. From this CHBR has been effective in navigating the obstacles between community and environmental conservation, implementing strategies that align with MAB’s vision of a BR while fostering community stewardship and environmental resilience.

Organizational Structure:

CHBR has adopted a Hub and Spoke leadership model, where the central hub serves as the primary leader while the spokes operate within a flat hierarchy . This structure ensures clear delegation of tasks and objectives, both for daily operations and long-term strategic growth . For example, one spoke specializes in environmental sciences, collaborating with various partners to support initiatives such as bat and green crab monitoring, research on endangered butterfly species, and the 4CAST project, which integrates climate change research with community engagement . Another spoke focuses on videography and content creation to craft narratives and raise awareness among a broader audience. A third spoke concentrates on tribal law, fostering connections with other community groups to build sustainable, long-term relationships.

By deploying this organizational structure, different personnel can approach many of the challenges highlighted previously from a community and environmental perspective. With this, CHBR is better able to convey the mission of MAB while inspiring and incentivizing community members to become more aware and engaged in the dichotomy between humans and the natural world.

The organizational structure of CHBR offers flexibility to engage in diverse projects, topics, and events that set it apart from other Biosphere Regions within the USBN. The central hub in its Hub and Spoke leadership model is led by a retired individual, with many of the spokes also being in a similar position. For those who are not retired, CHBR can hire their services to advance the Biosphere Region's mission. This abundance of available time as a resource enables CHBR to seize opportunities and strategically plan for the future. Whether organizing symposiums that draw hundreds of community members, researchers, and environmental stewards, or hosting sand art events and summer educational programs, CHBR has the organizational structure and flexibility to effectively develop, plan, and execute initiatives with great success. Additionally, by hiring individuals with expertise in specific disciplines, CHBR is better positioned to address targeted needs within the Biosphere Region and expand its impact.

A key component of CHBR's organizational structure is the diverse and specialized expertise that each member brings to their respective disciplines. At the center of the Hub and Spoke model is an individual with a background in business, skilled in brand development, storytelling, fostering partnerships, and managing finances to drive impactful changes on the ground. Among the spokes, one member is an expert in videography, another is a trained environmental scientist, and a third has extensive education and professional experience in tribal law. This unique blend of knowledge, skills, and perspectives strengthens the organization, enabling it to effectively pursue its goals and address complex challenges.

What They Did:

In examining the diverse and nuanced strategies employed by CHBR to mitigate tensions between the community and environmental conservation efforts, several critical themes emerged: (1) robust organizational structures, (2) active institutional engagement, (3)

prioritizing listening and learning from the community, and (4) implementing Te Kawa o Te Urewera trainings. These elements have been instrumental in guiding CHBR's success over the last several years.

Institutional Engagement:

Institutional outreach has been a pivotal strategy for CHBR in overcoming the common tensions between communities and environmental conservation efforts. By fostering partnerships with key institutions, CHBR has been able to bridge gaps in understanding and engagement, creating opportunities for collaboration that benefit both the community and conservation goals. For example, CHBR worked closely with the City of Lincoln to expand eco-tourism initiatives, which not only supported local economic growth but also raised awareness about environmental preservation . Collaborations with Oregon State University enhanced environmental research and conservation efforts, while partnerships with the Newport Aquarium provided educational programs and expertise to engage the community in meaningful ways. These institutional connections allowed CHBR to cast a wider net in attracting participants to its programs and events, such as symposiums, sand art activities, and summer educational initiatives. By leveraging key institutional resources, knowledge, and networks, CHBR has been better equipped to help address community concerns while promoting conservation practices.

Te Kawa o Te Urewera Training:

CHBR has also taken a novel approach in understanding the dynamics between community and their environment by working, living, and learning from New Zealand's Māori people. The Māori emphasize that its not just about connecting people to nature but rather building a meaningful, long-term relationship. From this perspective, the exchanges between nature and community need to be based on reciprocity, not dominance, and encourages asking people who engage in the community what they can give back rather than what they can take.

This encounter has shifted the way CHBR views natural systems as not just resources but living beings with their own lives. This is a critical step that really highlights the transition from viewing nature as something to be managed to recognizing our social responsibility within the ecosystems that we inhabit. From this CHBR has been creating programs that develop future ambassadors for the BR through engaging the community in meaningful ways, such as art and hands-on activities which help develop a sense of ownership and responsibility. Utilizing the diverse mix of experiences and expertise within CHBR's organizational structure has aided in their ability to convey the narrative that coexistence and engagement between the neighboring communities and their natural environment.

Learning and Listening

A cornerstone of CHBR's success lies in its commitment to actively learning from and listening to the community. This approach reflects their dedication to understanding the

needs, concerns, and perspectives of local residents regarding Biosphere Regions and how these regions can foster meaningful connections between people and the natural environment. CHBR recognizes that building trust and fostering collaboration requires open dialogue and a willingness to adapt based on community input.

To achieve this, CHBR has employed a variety of engagement strategies, including conducting formal qualitative interviews with permanent community members, initiating conversations with participants at events and programs, and collaborating with local business owners. These efforts have allowed CHBR to identify key areas of deficiency, such as gaps in community awareness about Biosphere Regions and limited engagement with conservation initiatives. Additionally, these interactions have revealed broader themes related to community priorities, challenges, and opportunities for partnership, which are explored further in the “Key Theme Findings” section of this case study.

Through these engagements, CHBR has not only gained valuable insights but has also increased community awareness of its mission. Residents have become more informed about the conservation and community programs CHBR is implementing or planning to implement, as well as the organization’s efforts to address tensions between communities and environmental conservation. By fostering open communication channels, CHBR has strengthened its ability to create programs that align with both ecological goals and community needs, ultimately helping bridge the divide between conservation efforts and local priorities. This ongoing process of listening and learning underscores CHBR’s role as a catalyst for collaboration and mutual understanding within the region.

Key Theme Findings:

The CHBR is actively working to fulfill its Core Mission of creating stewards while balancing Conservation efforts with Sustainable Development opportunities. The organization is focused on engaging students from elementary through college levels, aiming to spark interest in fields like forestry, marine science, and environmental monitoring that are not as prevalent in the area. This aligns with their Community Building efforts and demonstrates the Value of the biosphere to the community. To ensure longevity within this space, K through 8th grade education programs spanning classroom engagement to eLearning to summer camps and workshops have been developed and successfully implemented. Despite limited resources, CHBR has been successful getting buy-in from stakeholders within the education, conservation, and local government perspective enabling them to expand their reach and local community impact.

The CHBR faces challenges in Community Awareness, as it is still largely a "hidden treasure" within the local population. Many residents and workers are unaware of living in a UNESCO-designated area in their day-to-day lives. To address this, the organization is working to increase visibility through branding and signage, drawing inspiration from other Biosphere Reserves while also collaborating with organizations within the community and through hosting in person conference style presentations, annual sand art series, and

eco-tourism. This effort to improve awareness is crucial for the long-term success of the CHBR and highlights the importance of effective communication strategies.

In terms of value CHBR has in the community, the CHBR sees potential in creating new job opportunities, particularly in tourism-related businesses or in conservation. Like many vocations beforehand, conservation roles did not originally exist and have been propagated over time from engagement through institutions within the neighboring communities. By providing educational programs for elementary and middle school students in the forms of field trips and eLearning, partnerships with The Nature Conservancy and the Newport Aquarium, among hiring interns and other 3rd parties to lead eco-tourism are methods to inspire the younger generation while cultivating a community that sees the significance of the environment in which they live today.

Network Building is a crucial aspect of the CHBR's strategy. The organization has formed partnerships with key institutions such as the city of Lincoln City, the Aquarium, elementary schools, Oregon State University and the U.S. Forest Service. These collaborations are essential for conveying the Biosphere's message, expanding its influence, and leveraging resources. The partnership with the city of Lincoln City has been instrumental in providing initial funding and ongoing support, highlighting the importance of local government engagement in Biosphere initiatives. With the power of their network, ecological programs focused on bat and green crab monitoring are examples of the many outcomes that have arisen from these partnerships and the power of the network.

Regarding the ongoing challenges, CHBR faces many with the focal point on engaging with specific community groups, particularly those who may perceive the Biosphere designation as a threat to traditional industries or land use. Using the logging industry as an example, for decades has been a prominent economic driver for multi-generational community members that otherwise wouldn’t have a source of income. Using the language “reserve” has insinuated that just like the parks, this land that is a part of the community is there for the taking and not for the community to be stewards of. With this example, local groups have voiced their concerns and resistance to the reserve and thus have refrained from engaging with CHBR in its entirety. The same can be said for the local indigenous tribes that are absent from the table but have reserved seats. Acknowledging it takes time, effort, and understanding to cultivate trust for these relationships to grow, an increased directed effort is required with mutual parties to begin overcoming these major obstacles within the community.

Analyzing CHBR’s capacity, they have received funding support from the city of Lincoln City, with an initial funding of $6,500 for events. This ongoing support has been crucial for the organization's program activities and growth. Additionally, funding from organizations like NOAA have been essential in years prior enabling them to grow to and be more engaged in the community. There are limitations in terms of human resources and time, which can impact the organization's ability to fully engage with all interested volunteers and

community members. However, with changes the United States's Federal Administration, reliance on grants from traditional donors such as NOAA are no longer present and need for capacity building will have to stem from the communities themselves. With many of the community members being retirees, upper middle class, or tourists, the opportunity for growth is ever present, but in order to increase the overhead required for CHBR to expand its reach and growth, creative methods for donor or revenue generation is needed.

Key Takeaways:

1. Community Engagement: CHBR's educational programs and community events have increased awareness and engagement.
2. Sustainable Development: The Biosphere designation has potential economic benefits, particularly in sustainable tourism.
3. Network Building: Partnerships with local institutions are crucial for expanding influence and leveraging resources.
4. Challenges: Addressing community concerns and perceptions remains an ongoing challenge.

Recommendations:

1. Listening and Learning

a. Conduct structured interviews with representatives from various community groups, including residents, local businesses, indigenous leaders, and youth organizations.
b. Use these interviews to identify specific concerns, priorities, and opportunities for collaboration.
c. Incorporate feedback into planning processes to ensure programs align with community values and needs.
d. Hold recurring and scheduled meetings with community members once buy in is relatively established
    i. Make these meetings efficient and effective where members have a clear understanding of the Biosphere Region's mission, quarterly and annual objectives, and what action items members can take to support this strategy.

2. Intentional Institutional Outreach

a. Approach potential partners with a clear narrative on the Biosphere Region's mission, objectives, and have specific asks for that partnership to support the strategy of the Biosphere Region.
b. A clear indication on how that partnership fits with the Biosphere Region and adds value to their mission is essential for positive first impressions and long-term success.

3. Co-creation of Community Events and Programs

a. Organize brainstorming sessions or focus groups where community members can share ideas for events that resonate with their interests and cultural values.
b. Use interactive methods like surveys or participatory mapping to gather input on preferred activities or event themes.
c. Foster long-term partnerships through structured, recurring events that residents, tourists and more can plan and engage in future years.
d. Ensuring community events focus on accessibility and broad appeal. Events should be fun and need to captivate the participants. Once you have their attention you can then bake in targeted programs and education.
e. Build relationships first, offer education second.
    i. Create a positive shared narrative highlighting their mutually beneficial relationships between people and their local ecology.

4. Effective Organizational Structure

a. Clear hierarchy and role assignment:
    i. Understanding the current state of the organization based on knowledge, skills, and experiences for their respective areas of focus.
    ii. Clear direction on the organization, its mission, and milestones only a quarterly and annual basis.

Chapter 4: GIS Database Construction and ArcGIS StoryMap

Geospatial data is an effective tool that leverages locational data with a diversity of qualitative and quantitative metrics that create innovative outputs to discern patterns, relationships, and conclusions that would otherwise be inaccessible. During the last UNESCO Periodic Review process in 2016, USBN collected each of their twenty eight biosphere's shapefiles. These shapefiles followed the proper protocols required by the MAB programme and were stored in a private sharepoint drive. However, in 2018, the United States withdrew from UNESCO under direction from President Trump causing both USBN and UNESCO to lose ownership and access to these crucial shapefiles. The remaining data were the non-geolocated PDFs of the biospheres and whatever individual biosphere's retained independently.

This situation reflects a broader issue common to many long-standing networks: the absence of a designated, centralized storage system for geospatial data. Without clear data stewardship protocols in place, vital information often becomes fragmented, lost, or inaccessible. Not only does this cause issues when data is needed in the future, but it also hinders current-day collaboration, continuity, and biosphere management. The SEAS GIS team sought to rectify this issue.

Shapefile Acquisition and Validation

The loss of the shapefiles presented the SEAS GIS team with our first deliverable: to procure, digitize, and centralize the data management of these twenty eight biosphere shapefiles. Our crucial team members reached out to individuals from each biosphere in an attempt to recreate this database for USBN and MAB. We met a three major barriers as we sought out shapefiles:

1. Individual biospheres did not have any shapefile in their possession.
2. Individual biospheres had shapefiles, but were low quality and contained topological issues (Figure 4)
3. Individual biospheres had shapefiles without zonations (Figure 5)

In a few cases, biospheres retained complete, well-organized spatial datasets, which served as a valuable reference and starting point for rebuilding the broader network's geospatial foundation. To track our progress and document the variability within our acquired shapefiles, the SEAS GIS team compiled a summary of the shapefile status for each of the twenty US biosphere regions. The table below outlines the source of each shapefile, the condition of its zonation, and any additional processing or reconstruction that we completed. This table highlights the fragmented nature of geospatial data across the network, but also the collaborative efforts that were required to rebuild the network's spatial foundation.

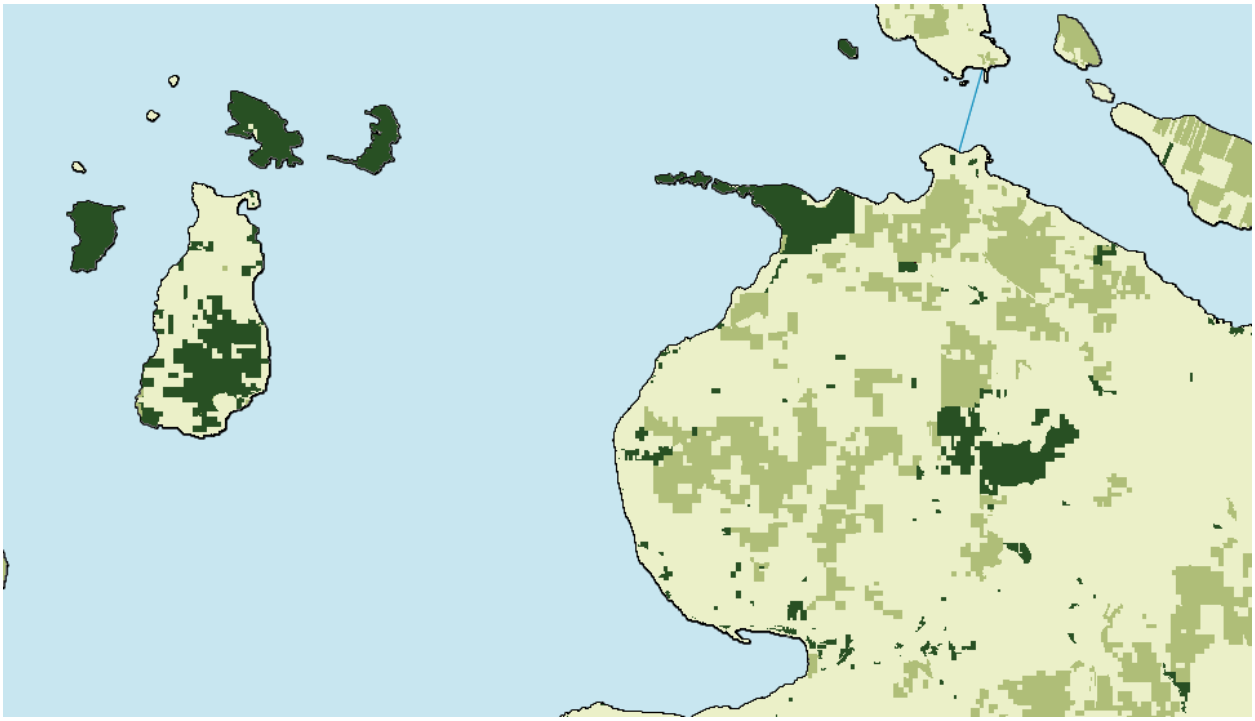


Figure 4: Obtawaing Biosphere Native Shapefile. The previous user of this shapefile used the geoprocessing tool 'Polygon to Raster.' The output had every pixel of the biosphere region individually identified. Our team smoothed any holes and irregularities to produce a cleaner, more accurate file.

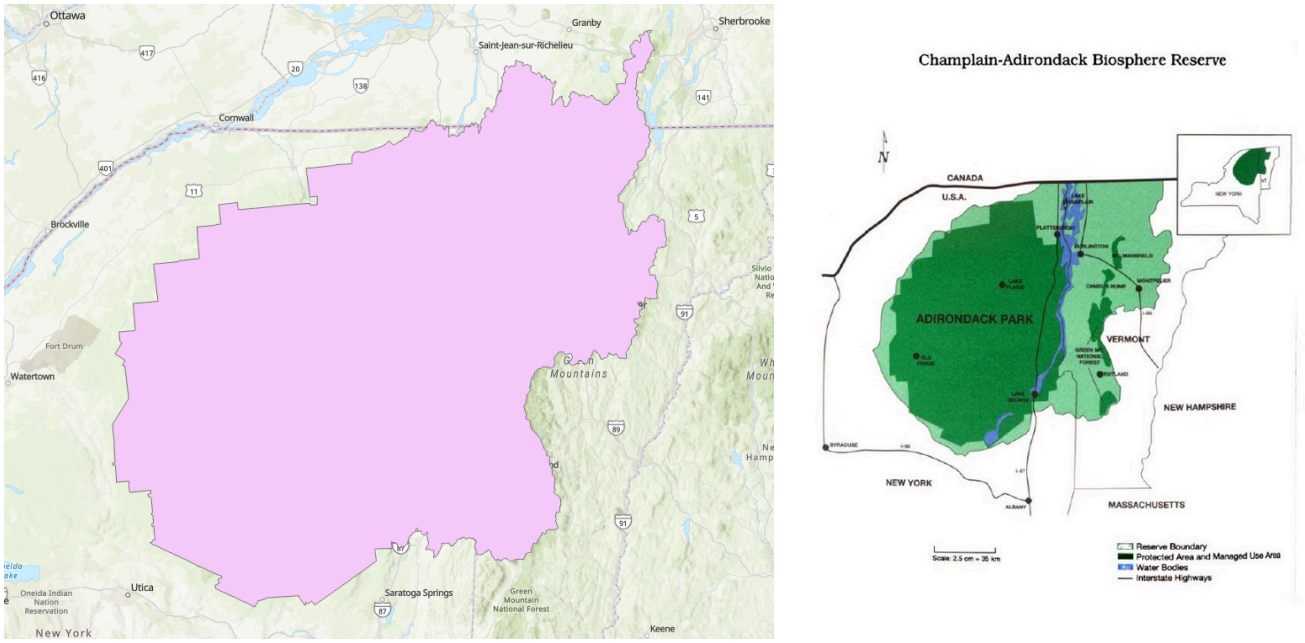


Figure 5: Champlain Adirondack Biosphere Region Native Shapefile (left) and 2016 PDF (right). The provided shapefile from the biosphere was only the boundary and the pdf did not contain complete zonation, notably combining the core and managed use areas. Our team georeferenced the PDF, created features, and found shapefiles from the states of New York and Vermont to match Adirondack Park and various state parks.

Biosphere Region	Shapefile Source	*Quality	Processing Technique
Apalachicola	Biosphere Region	Average	Merging, dissolving, erasing, clipping and removal of discrete polygons
Big Bend	Biosphere Region / 2016 Periodic Review	Partial Boundary Only	Managed Use / Area of Coop. reconstructed using the 2016 Periodic Review
Big Thicket	Graham Klag	Average	Merging, dissolving, and erasing discrete polygons
Cascade Head	Graham Klag	Average	Merging, dissolving, and erasing discrete polygons
Champlain-Adirondack	Lake Champlain Basin Program / 2016 Periodic Review	Boundary Only	Core/Managed Use and Area of Coop reconstructed using 2016 Periodic Review
Channel Islands	Sean Hastings (NOAA / 2016 Periodic Review	Average	Managed Use and Marine Zones reconstructed using MR/ MPA Inventory
Congaree	Biosphere Region	Average	Merging, dissolving, and erasing discrete polygons
Crown of the Continent	Crown of the Continent Research Learning Center	Poor	Major Merging, dissolving, clipping, and erasing discrete polygons
Denali	Denali National Park and Preserve GIS Portal	Good	Minor Merging, dissolving, and clipping of polygons
Everglades and Dry Tortugas National Park	South Florida Natural Resources Center	Poor	Major Merging, dissolving, clipping, and erasing discrete polygons
Glacier Bay	N/A	N/A	After multiple attempts to gain this shapefile, it was not shared due to concerns of mapping indigenous communities
Golden Gate	Biosphere Region / 2016 Periodic Review / Created from scratch	Boundary Only	Core/Managed Use/Area of Coop reconstructed from 2016 Periodic Review and GIS data
Guanica	Graham Klag / 2016 Periodic Review / Created from scratch	Reconstructed	Core, Managed, and Cooperation areas recreated from scratch
Hawaiian Islands	Biosphere Region	Poor	Major Merging, dissolving,

			clipping, and erasing discrete polygons
Isle Royale	Created from scratch / 2016 Periodic Review / Cliff McCreedy	Reconstructed	Validated through 2016 Periodic Review and created using existing GIS data
Jornada	USDA-ARS Range Management Research Unit	Good	Minor Merging, dissolving, and clipping of polygons
Luquillo	Graham Klag / 2016 Periodic Review / Created from scratch	Reconstructed	Used georeferenced PDF, 2016 Periodic Review, and existing GIS data to reestablish zonation
Mammoth Cave	Chris Groves / Western Kentucky University	Good	Minor merging, dissolving, and erasing discrete polygons
Mojave Desert	Cliff McCreedy / National Park Service	Partial Boundary Only	Validated through 2016 Periodic Review and created zonation using existing GIS data
NJ Pinelands	Paul Leaken / NJ Pinelands Commission	Good	Minor merging, dissolving, and erasing discrete polygons
Obtawaing	Shannon Brines / University of Michigan	Poor	Major Merging, dissolving, clipping, and erasing discrete polygons
Olympic	Olympic National Park / 2016 Periodic Review	Partial Boundary Only	Zonation reconstructed from 2016 Periodic Review and additional GIS data
Rocky Mountain	Cliff McCreedy / Rocky Mountain NPS	Average	Merging, dissolving, and erasing discrete polygons
Sequoia Kings Canyon	Existing GIS data / 2016 Periodic Review	Reconstructed	Core, Managed Use, and Area of Coop. reconstructed from 2016 Periodic Review and additional GIS data
Sonoran Desert	2016 Periodic Review / International Sonoran Desert Alliance / Created from scratch	Reconstructed	Used georeferenced PDF and 2016 Periodic Review to create the zonation from scratch
Southern Appalachian	Evin Carter / Oak Ridge National Laboratory	Poor	Major Merging, dissolving, clipping, and erasing discrete polygons
Virginia Coast	Susan Bates / The Virginia Coast Nature Conservancy	Poor	Major Merging, dissolving, clipping, and erasing discrete polygons

Yellowstone-Grand Teton	Graham Klag / 2016 Periodic Review	Average	Merging, dissolving, and erasing discrete polygons

Table 2: Acquisition method, quality, and method of processing and creation of U.S. Biospheres

*Poor Quality: These shapefiles took ≥15 hours to completely fix and process. They exhibited major problems including being a raster instead of a vector, sliver polygons, unknown zoned gaps, or unknown overlaps.

*Average Quality: These shapefiles took 5-15 hours to completely fix and process. They exhibited typical topological problems that required a tender hand, but not to the time extent that poor shapefiles did.

*Good Quality: The shapefiles took ≤5 hours to completely fix and process. The native shapefile had minor topological issues.

Acquiring these shapefiles was only the first step. Our team needed to ensure that the newly assembled database was accurate, up-to-date, and consistent across the entire network. Using MAB's requirements, we modified all the shapefiles so they adhere to the technical standards outlined in the nomination and periodic review process. This included:

1. **Zonation Accuracy:** Each biosphere reserve's shapefile needed to reflect the latest MAB-ICC approved zonation, with precise boundaries that avoided gaps, overlaps, and self-intersecting polygons.
2. **Geometric Integrity:** We corrected spatial errors such as slivers, unenclosed rings, and misaligned boundaries to ensure a topologically sound database.
3. **Attribute Standardization:** The attribute table for each biosphere region was structured to clearly label each of the three zones - Core, Managed Use Area, and Area of Cooperation/Partnership.
4. **Projection Standardization:** All biosphere region shapefiles were set to the WGS 84 coordinate system (ESPG: 4326).

To determine the integrity of each shapefile, our team exported these shapefiles into feature datasets to create topologies. A topology allows us to define and enforce spatial relationships between features within the feature dataset. The SEAS GIS team checked two major topological requirements for biosphere zonation polygons:

1. Must Not Overlap and
2. Must Not Have Gaps.

These two rules ensure that land stewardship is properly represented and future usage of these shapefiles will produce accurate and effective outputs. Biosphere regions are able to produce innovative and useful outputs such as Golden Gate Biosphere Network's Climate Change Vulnerability Assessment with up-to-date and accurate geospatial data.

By adhering to the MAB guidelines, our team reconstructed a critical dataset for USBN while also establishing a framework for maintaining and updating spatial data for future biosphere regions that may arise. This newly assembled database will serve as a key resource for biosphere regions across the network to ensure their work is rooted in accurate spatial

data. This geodatabase is being housed in multiple locations to ensure USBN does not lose access to this dataset again. These locations include a private MAB Microsoft Sharepoint, a private ArcGIS Online Group, and zipped folders in the possession of Cliff McCreedy and Jon Allan. Our ArcGIS Online Group is organized via tags for each biosphere region.

Map Automation

In the process of reviewing previously submitted Periodic Reviews, the SEAS GIS team noticed there was not a universal format for displaying each biosphere region's zonation. Each biosphere depicted MAB's zonation differently. By adhering to MAB's requirements, our team was able to create a standardized format that would increase compatibility between biosphere regions. Our standardized format included the following criterion:

- Title indicating the highlighted biosphere (Font stylized using the USBN Style Guide).
- A north arrow, scale bar, and the USBN logo.
- An inset map to show geographic context.
- A legend with a uniform color scheme for the Core, Managed Use, and Area of Cooperation and Partnership zones.
- A hybrid basemap to give map users an idea of what local lands are included within the biosphere.
- All data projected in the World Geodetic System 1984 geographic coordinate system.

To produce formalized maps, we created an ArcPython map automation script that has outputs for the twenty seven biosphere shapefiles we acquired. The outputs for this included a geolocated PDF and an APRX file, an ArcGIS Pro project file that includes an editable map and layout for biosphere GIS users to add data or additional map elements, such as hectares per zonation or land ownership partners information. An example of the formalized map for the Sonoran Desert Biosphere Region can be seen above. Examples for all other biosphere maps can be found within Appendix E. The ArcPython script we utilized can be found in Appendix F.

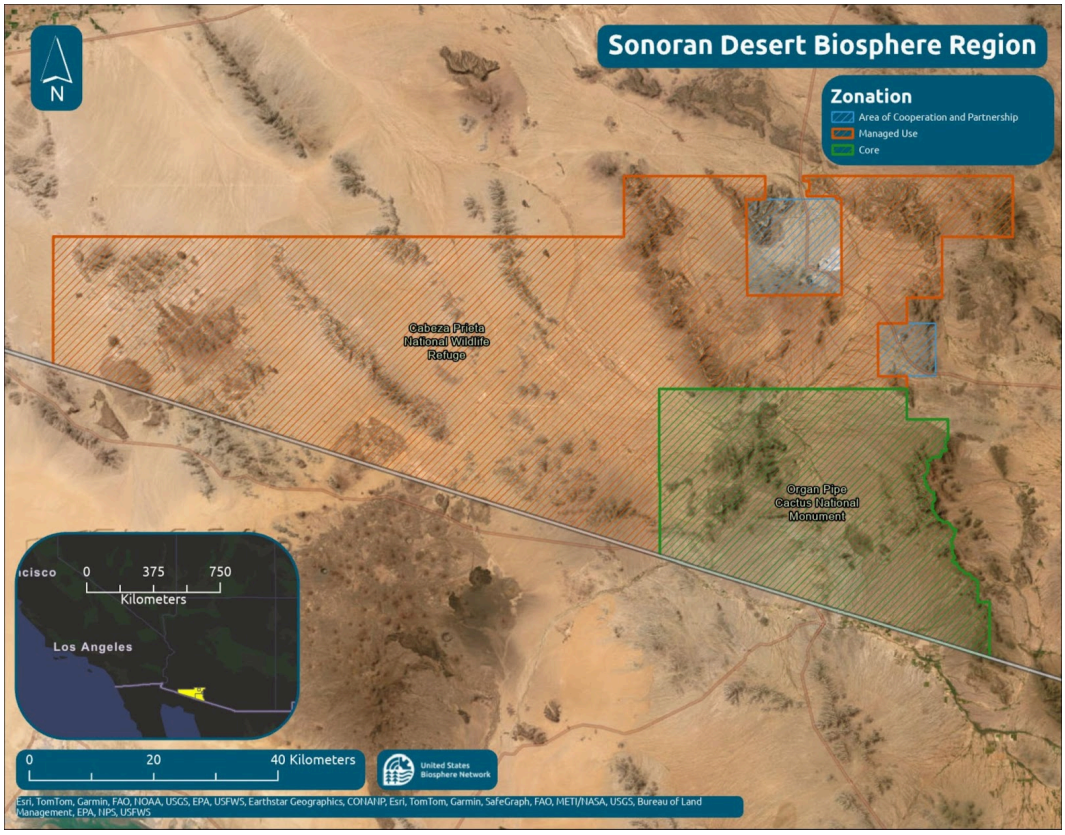


Figure 6: Output of map automation script for Sonoran Desert Biosphere Region

ArcGIS StoryMap

The final component of the GIS team's contribution to this project was an ArcGIS StoryMap. This StoryMap acts as a landing page for any and all interested in learning about USBN. We strategically curated the language to be as accessible as possible, trying our best to follow Web Content Accessibility Guidelines (WCAG) 2.0, which derives its graded reading levels from the International Standard Classification of Education from UNESCO. The StoryMap is graded to be read at a seventh to ninth grade level.

Our team worked with Cliff McCreedy to select six biospheres across the network to highlight since the inclusion of twenty eight biospheres into a single StoryMap was outside capacity. These biospheres were selected on two basic criteria:

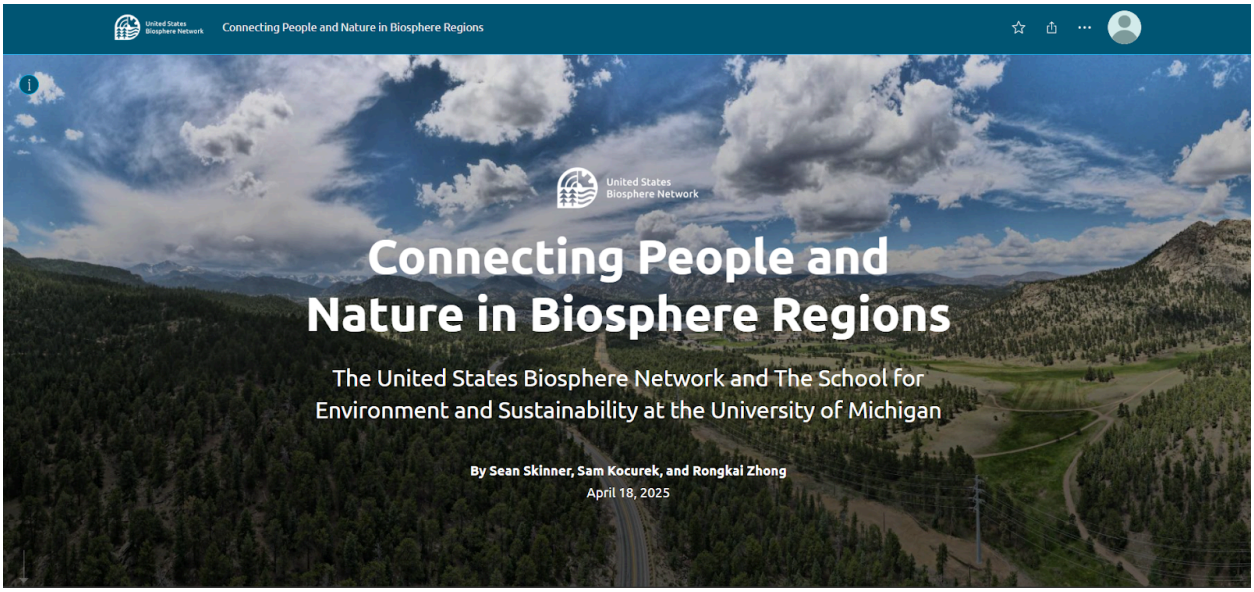
1. That they are representative of the various ecotypes across the United States, and
2. That they are embracing the missions of MAB and completing innovative conservation projects.

As a result, we highlighted Cascade Head, Golden Gate, New Jersey Pinelands, Sonoran Desert, Mammoth Cave, and Champlain-Adirondack Biosphere Regions. Since the GIS team could not visit each of the biosphere regions in-person, we leveraged the travel of the SEAS

Qualitative team to gain a more intimate understanding of the respective biosphere regions. Acting as a springboard, this facilitated the GIS team to create unique web maps for each of the biospheres. We then met with each of the six biospheres independently to workshop the web maps and ensure that their region was represented in an honest and genuine manner. To ensure seamless transitions between map slides within our map sidecars, we imported each biosphere region's feature classes into one web map per respective region. Instead of fading into each subsequent map, the StoryMap platform will now jump around the basemap to each feature class giving viewers an immersive experience over the landscape.

To follow proper branding, we also created a custom USBN Theme in ArcGIS Online based on the USBN Communications Toolkit. The colors are in hex codes.

- Background Color: #005976
- Accent Color: #00A7BD
- Optional Accent Color: #9ECC3F
- Optional Accent Color: #F0CB32
- Header Background: #005976
- Header Text: #F1F6F8
- Text Font: Ubuntu, bold for headers
- Button Style: Tertiary button style with very rounded corners
- Quotes: Default
- Links: Link style with a single, dashed underline
- Separators: Separator style with a single, solid line, Full width of screen



- Header Text Color: #9ECC3F
- Paragraph Text Color: #F1F6F8
- Spacing: Spacious block spacing
- Basemap: Imagery Hybrid
- Logo: White Lettered USBN Logo

Figure 7: Header and Title of the ArcGIS StoryMap

Sources for text, photos, and media contained within our StoryMap can be found in

Appendix H(StoryMap Data References), Appendix I (StoryMap Text References) and Appendix J(SEAS-USBN Media Guide).

StoryMap Development Methodology

In total, our StoryMap hosts twenty four web maps. These interdisciplinary web maps convey the range of habitats, communities, and projects occurring within these unique biospheres. To ensure that the StoryMap is understood and managed properly past the SEAS team's creation, we wrote out the method and data source for each of the twenty four web maps. This ensures our methods are replicable should components of the StoryMap ever expire or become stale.

Introductory Biosphere Map Tour

1. Assessed accuracy of initial biosphere boundary shapefiles provided to our team by Graham Klag
    a. Edited BR_Label field to reflect the change in biosphere reserve to biosphere region
    b. Merged polygons of the same biosphere into one feature (N_SouthernAppalachia + S_SouthernAppalachia + E_SouthernAppalachia + W_SouthernAppalachia = SouthernAppalachia)
2. Used the "Feature to Point (Data Management)" geoprocessing tool to convert polygons to a points layer called "USBN_StoryMap_Tour".
    a. Checked box for inside so that the newly created point would be placed within the boundaries of the respective biosphere
3. Added Description, Photos, Attribution, and AlternativeText text fields to the points layer:
    a. Description – a field containing a short paragraph explaining when the biosphere was established and what makes the biosphere unique from the others within the network. (These paragraphs were provided to the GIS team by Katie Darr, a former member of the USBN Communications Team. They were intended to be used on the USBN website, but found a new home with our StoryMap).
    b. Photos – a field to manual type the name of a photo (ex: CascadeHead.jpg) for each biosphere.
    c. Attribution – a field to display who should be credited for taking each biosphere's respective photo. (ex: Photo provided by the Cascade Head Biosphere Collaborative).
    d. AccessibilityText – a field to display a brief text description for each image that screen readers can read aloud for people with visual impairments. (ex: An aerial view of beaches with forest along the water).
4. Procured photos for each biosphere from various copyright free locations or with

permission from original photographers. Photos were placed into a folder titled "USBN_StoryMap_Tour_Photos". Sources included NPS Photos, USBN Communications Google Drive, and others. A more in depth guide for all photos and videos within our StoryMap can be found in the UM-SEAS USBN StoryMap Photo/Media Guide.

5. Used the "Enable Attachments" and "Add Attachments" geoprocessing tools on the biosphere points layer to let each biosphere's photo be viewed when clicking on individual points. With the photos now merged with the points layer, the original folder does not need to be stored within ArcGIS Online. Uploaded points to ArcGIS Online Group as a feature layer.
6. Within ArcGIS's StoryMap Creator, we added a Map Tour under the immersive media section and selected the "Start with a feature layer" option to use the "USBN_StoryMap_Tour" points layer. With the Map Tour now properly imported, the following selections were made to increase readability and flow of our introductory section.
    a. Tour Layout – List - This allows users to view biospheres in any order of their preference
    b. Place Title – Pulls from the field "BR_Label" to display the proper name for each biosphere
    c. Place Description – Pulls from the field "Description" to allow users to read an introductory paragraph for each biosphere
    d. Image Placement – Fill – Crops images to the same dimensions to increase compatibility and enhance overall design
    e. Attribution – Pulls from the field "Attribution" to allow user to hover over an image icon to see photographer credits
    f. Alternative Text – Pulls from the field "AlternativeText" to allow users who use speech readers to gain an understanding of what the biosphere might look like
    g. Image Source – Attachments – Pulls from previously merge photos linked to each point
    h. Sort by – Place Title (alphabetical) – Displays biospheres in alphabetical order
    i. Basemap – Standard Imagery – Removes political boundaries from basemap
    j. Point Color – Yellow – Makes each point vibrant against basemap background
    k. Initial Zoom Level - Automatic – Automatically zooms to an extent where all biosphere are visible when users enter the Map Tour section

Cascade Head Biosphere Region

Marine Conservation in Cascade Head

1. Brought shapefiles for the Area of Cooperation and Partnership for Cascade Head Biosphere Region and the 2023 NOAA Marine Protected Areas Inventory Dataset

into ArcGIS Pro

2. Using the Select by Location tool, we selected MPAs that intersected with the outer boundary of the Cascade Head Biosphere. Once filtered, we exported the selected features into a new feature class to represent the MPAs and MRs that occur within the Cascade Head boundary. Changed symbology for both layers to show map users that each zone is clearly defined by specific NOAA regulations. Uploaded these layers as a web map to ArcGIS Online and imported into the StoryMap.
3. To give StoryMap users a sense of what lies below the ocean surface, we imported the Pacific States Marine Fisheries Commission's West Coast USA Nearshore CMECS Substrate Habitat dataset. This includes data on the type of substrate present within the MPAs and MRs.
    a. This layer was clipped to the boundary of the MPAs and MRs within the biosphere region. Symbology labels were also changed into terminology that a broader audience could understand.
        i. Rock Substrate = Rock
        ii. Coarse Unconsolidated Substrate = Gravel
        iii. Fine Unconsolidated Substrate = Sand
        iv. Biogenic Substrate = Shell/Kelp Beds
4. Final layer was uploaded to ArcGIS Online and added to the StoryMap as a media action. This creates a button within the StoryMap that users can click to zoom into the MPAs and MRs to reveal the present substrate.

Monitoring in the Salmon River Estuary

1. Imported shapefiles from the Pacific States Marine Fisheries Commission's 2022 European Green Crab Status Monitoring dataset into ArcGIS Pro.
2. Using the Select by Location tool, we selected points within the EGC Observation Status layer that intersected with the outer boundary for Cascade Head. These selected points were exported into a new dataset we titled "EGC Trapping Locations".
    a. Because there are multiple traps at each site (overlapping point data), we trimmed our dataset down to have only one point for each site.
    b. Symbology was changed to a white circle point with a vector image of a green/blue crab at the center.
    c. The polygon representing the Salmon River Estuary was also extracted from this dataset. This was titled "Salmon River EGC Observation Area". Symbology was changed to a blue gradient to represent the change from saltwater to freshwater within this habitat.
3. Final layers were uploaded to ArcGIS Online and added to our StoryMap

Hiking in the Cascade Head Biosphere

1. Via the Cascade Head Biosphere Collaborative's website, our team found a U.S.

Forest Service Map showcasing trails within the Siuslaw National Forest.
    a. Upon importing this PDF into ArcGIS Pro, we were able to georeference this map to the Cascade Head Biosphere so both layers would overlap.
2. Within the Cascade Head geodatabase, we created a feature polyline feature class titled "CascadeHead_Trails" and points feature class titled "CascadeHead_Trailheads".
3. Using this new feature class, we were able to digitize trails, trailheads, and the USFS Road 1861. Trails included:
    a. The Nature Conservancy Cascade Head Trail
    b. Hart's Cove Trail
    c. Rainforest Trail
4. Each trail was given a specific color to differentiate them from each other, as well as a label to tell map users the name of the trail and the mileage. The road was given a grey color and the trailheads were given a hiker icon to indicate the starting/ending points. No labels were given to these layers.
5. Final layers were uploaded to ArcGIS Online and added to our StoryMap

Nature Through the Artist's Eyes

1. Within the Cascade Head geodatabase, we created a points feature class titled "CascadeHead_Sandart".
2. Based on text, photos, and videos highlighting the Art on the Beach event, we were able to pinpoint that art was being drawn on the beaches of Lincoln City, Oregon.
3. Using the CascadeHead_Sandart points layer, we placed points across the beach. In reality, the points would be more spaced out to account for the size of these works of art. However, we placed them closer to each other to guide more map users on a more interactive experience.
    a. Using the Cascade Head Biosphere Collaborative's media gallery, aerial imagery of 11 different works of art were compiled into a folder.
    b. Used the "Enable Attachments" and "Add Attachments" geoprocessing tools to the Sandart points layer to let users click on the points to view the sand art from above.
    c. Symbology was changed to a white circle with a black camera icon in the center.
    d. Pop-ups were enabled so users can see the images and the title of each artwork.
4. Final layers were uploaded to ArcGIS Online and added to our StoryMap

Golden Gate Biosphere Region

Golden Gate Biosphere Network (GGBN) Partners Map

1. The native map file provided by the Golden Gate Biosphere Network.
2. We reduced attribute fields to include: Partner Name, Acres, and Hectares. This provides viewers with the organization of stewardship
3. We then adjusted land and water symbology to unique values for spatial clarity of partners. Water was given a hatched view to differentiate marine and terrestrial areas.
4. We added the boundary of the Golden Gate Biosphere to understand where the partners are geolocated within the BR.

Water Availability Through the Century

1. A REST service URL is provided in GGBN Climate Change Vulnerability Assessment for all of their different models and GIS data within the report. We pulled out the climatic water deficit model to understand the change of water availability in the biosphere since GGBN identified water as a key area of focus.
2. We pulled "hiscwd_ave_tif baseline" V8 (1989-2010) for a baseline of water availability.
3. We also pulled the "miroc5cwd_tif" Model for Interdisciplinary Research On Climate (MIROC5 for 2100) to get a moderate projection of what water availability might look like at the end of the century in the biosphere.
    a. We renamed the raster for the baseline: Climatic Water Deficit - Historic
    b. We renamed the raster for projection: Climatic Water Deficit - Projected
4. Changed symbology from stretch to discrete so any adjustments in the symbology carry over to ArcGIS Online.
        a. Scale of symbology was adjusted so each time frame matched in scale and then adjusted the label from a quantitative measure to qualitative 'Low Water Stress' to 'High Water Stress' for ease of understanding.
5. Imported both maps into one Map Frame in the StoryMap utilizing the slider tool to see change over time with a matching scale of maps.
6. We added a sketch of text in AGOL displaying the timeframe in which each side of the slider represents:
        a. 'Water Availability from 1989-2100'
        b. 'Water Availability in 2100'

Water Flow Map

1. Digital Elevation Model (DEM) TIFF file "output_SRTMGL1.tif" obtained from DataBasin at 90m resolution.
        a. 90m resolution is coarse but finer resolution created processing issues on our desktops.
2. Clipped to Partners Map.
3. Geoprocessing tools:
    a. Used 'Fill' to remove any imperfections within the DEM and delineate drainage channels for the movement of a pixel of water.

b. Used ‘Flow Direction’ on the filled raster to create a new raster that indicates the direction in which each cell travels to its downslope neighbor cells. Kept standard D8 flow consequently.
c. Used ‘Flow Accumulation’ to apply weight total to each cell to understand where water in the region would pool.
d. Each output from the previous geoprocessing tool became the input raster for the subsequent tool. Because of the linear process of these geoprocessing tools, no strict naming conventions were followed. Final accumulation layer named FlowAcc_Flow1.

4. To verify accuracy of output, we imported a ‘California Streams’ line feature class from the Department of Fish and Wildlife. We obtained the data layer from their ArcGIS Online account. Darker pixels in this final flow accumulation model should congregate around streams.
    a. We clipped the streams layer (which is for the whole state) to the terrestrial part of the ‘GGBN Partners’ map.
    b. We also consolidated the attribute table for this line feature class to include:
        i. Stream Name
        ii. Mouth Latitude
        iii. Mouth Longitude
        iv. Hydrologic Subregion
        v. Hydrologic Unit Code (HUC)
5. Once verified, we applied discrete symbology and labeled lighter pixels on the spectrum to ‘Slow Water Flow’ and darker pixels to ‘Fast Water Flow.’

Bull Kelp Restoration

1. Using community-based observations from iNaturalist, a CSV was downloaded that included latitude and longitude, species name, and an image of the Bull Kelp from 2014-2025.
2. Using the XY Table to Point, CSV latitude and longitude data was converted into a points layer titled BullKelp_Observations.
    a. The pop-ups for these observations were:
        i. Date of Observation
        ii. Time of Observation
        iii. Date of Creation
        iv. iNaturalist URL
        v. Image URL
        vi. Latitude
        vii. Longitude
        viii. Scientific Name

ix. Common Name
x. Taxon Name

3. We pulled in the Golden Gate Biosphere's boundary to situate the viewer in the biosphere and where these observations are occurring.
    a. BullKelp_Observation was then clipped to the biosphere boundary
4. Duplicated layer for dual symbology. One layer was an untouched points layer of all the Bull Kelp observations within the biosphere. The other identical layer's symbology was adjusted to use 'Heat Map' symbology since ESRI automates the tool for you.
5. For the StoryMap, we have the heat map as the initial view so people can quickly identify the densest Bull Kelp habitat spaces. As a map action, you can switch on the points layer with individual observations that have additional attribute information.

Coast Redwood Suitability

1. A REST service URL is provided in GGBN Climate Change Vulnerability Assessment for all of their different models and GIS data within the report. We pulled out the Coast Redwood Habitat Suitability Model to understand the change of range of this iconic northern Californian species.
2. We pulled "SESE_MEANW_msk_GGBN_tif" V8 (1989-2010) for a baseline of habitat suitability.
3. We also pulled "SESE_meanw_miroc_esm_msk_GGBN_tif" Model for Interdisciplinary Research On Climate (MIROC -ESM for 2100) to get a moderate projection of what Coast Redwood habitat suitability might look like at the end of the century in the biosphere.
    a. We renamed the raster for the baseline: Coast Redwood Suitability Baseline
    b. We renamed the raster for projection: Coast Redwood Suitability in 2100
4. Changed symbology from stretch to discrete so any adjustments in the symbology carry over to ArcGIS Online.
    a. Scale of symbology was adjusted so each time frame matched in scale and then adjusted the label from a quantitative measure to qualitative 'Low Suitability' to 'High Suitability' for ease of understanding.
5. Imported both maps into one Map Frame in the StoryMap utilizing the slider tool to see change over time with a matching scale of maps.
6. We added a sketch of text displaying the timeframe in which each side of the slider represents
    a. 'Coast Redwood Suitability from 1989-2100'
    b. 'Coast Redwood Suitability in 2100'

New Jersey Pinelands Biosphere Region

New Jersey Pinelands Commission Long-term Monitoring and Research Projects

1. Imported the NJ Pinelands Commission's Long-term Monitoring and Research Projects dataset from their online portal and the Area of Cooperation and Partnership for the New Jersey Pinelands Biosphere in ArcGIS Pro
2. Using the Select by Location tool, we selected for research projects (layers) that intersected with the outer boundary of the New Jersey Pinelands. Once filtered, we exported the selected features into a new dataset titled "Pinelands Commision Research Sites".
3. Using unique values for the symbology, each type of research project was assigned a specific hex code to help users differentiate betweens projects. Projects included:
    a. Watershed Assessment Sites
    b. Right-of-Way Vegetation Sites
    c. Annual Frog and Toad Survey Sites
    d. Wide Water Quality Sites
    e. Continuous-record Water Level Monitoring Sites
    f. Partial-record Water Level Monitoring Sites
    g. Water Level Monitoring Wells
4. Pop-up were enabled to allow users to view what type of data the New Jersey Pinelands Commission is collected
5. Final layers were uploaded to ArcGIS Online and added to our StoryMap

Restoring Fire to the Forest

1. Imported the New Jersey Department of Environmental Protection's Prescribed Burn Notification Locations in New Jersey dataset into ArcGIS Pro.
2. Using the Clip geoprocessing tool and the outer boundary of the New Jersey Pinelands Biosphere, we were able to find the prescribed burns that were located within the boundary's interior. We use these extracted features to create a new feature layer titled "Pinelands_PrescribedBurns".
3. With the layer selected in the Contents Pane, we were able to view the Feature Layer tab. This allows us to access the Aggregation settings. Within Aggregation, we selected to use Clustering. This aggregates point features into dynamic point clusters that change in size depending on the scale you are viewing your dataset at. The largest point at our set scale would indicate greater than 57 prescribed burns sites, while the smallest point would indicate less than 2 prescribed burn sites.
4. Symbology was changed to better represent prescribed burn locations. Points were given a white background and red fire icon. A gray border was applied to all points.
5. Final layer was uploaded to ArcGIS Online and added to our StoryMap

Berries of the Pinelands

1. Imported the New Jersey Department of Environmental Protection's 2020 Land Use/Land Cover of New Jersey dataset into ArcGIS Pro.
2. Using the Clip geoprocessing tool and the outer boundary of the New Jersey

Pinelands Biosphere, we were able to exclude and landcover polygons that existed outside the Area of Cooperation and Partnership. The new feature class was called LULC_Pinelands_Clip.

3. Using the Select by Attribute tool, we were able to extract modified agricultural wetlands from the larger LULC dataset using the following clause: Where LABEL20 is equal to AGRICULTURAL WETLANDS (MODIFIED). With these wetlands now filtered out, we exported our selection using the Export Features tool and titled it Pinelands Agricultural Wetlands.
4. Symbology was changed to a yellow dashed outline to give users a sense of where these agricultural wetlands are located.
5. Final layer was uploaded to ArcGIS Online and added to our StoryMap.

Wildlife Conservation in the Pinelands

1. Using community-based observations from iNaturalist, a CSV was downloaded that included latitude and longitude, species name, usernames, and an image of the Pine Barrens Tree Frog.
2. Using the XY Table to Point, CSV latitude and longitude data was converted into a points layer titled Pinelands_Treefrog_Observations.
3. With the newly created points feature class, our team used the Kernel Density tool to create a heatmap that highlighted higher and lower densities of Pine Barrens Tree Frog observations. Within a heatmap, warmer colors indicate higher densities and cooler colors indicate lower densities. Within the Kernel Density tool, we set the population field to none because each point represented one observation and the output cell size was decreased to 0.001 to produce smoother levels within the heatmap. The raster heatmap was not clipped to the biosphere boundary to highlight that species movement is not defined by a political boundary.
4. Using Classify Symbology, we broke the heatmap into 10 levels using the Manual Interval method and applied a color scheme ramp that ranges from transparent, light blue, red, orange, and yellow. The base color was set to transparent because this was the absence of Pine Barrens Tree Frog observations. Labels were set to Low, Medium, and High. Resampling type was set to Cubic that determines the new value of a cell based on fitting a smooth curve through the 16 nearest input cell centers. This also smooths the intervals of our heatmap.
5. Finalized raster layer was uploaded to ArcGIS Online and added to our StoryMap.
6. In addition to our heatmap, our team wanted to highlight individual treefrog observations. To do this, we filtered all iNaturalist observations into categories, image observations and sound observations. Using the Select by Attributes we filtered using the following clauses: Where SOUND_URL is not null and Where PHOTO_URL was is not null. These selections were used to produce two new points layers, Pinelands iNaturalist Sound Observations and Pinelands iNaturalist Photo

Observations. Pop-ups were configured and enabled to include the following:
    a. Observation Date
    b. iNaturalist Username
    c. iNaturalist Observation URL
    d. Image or Sound URL
    e. Species Scientific Name
    f. Species Common Name
7. Symbology for each layer was changed to help map users recognize the difference between the image and sound points.
8. Final layer was uploaded to ArcGIS Online and added to the StoryMap as a media action. This creates a button within the StoryMap that users can click to switch between the heatmap and the individual points layers.

Sonoran Desert Biosphere Region

The Role of Rain in Arid Landscapes

1. Imported PRISM (Parameter-elevation Regressions on Independent Slopes Model) Climate Group's average annual precipitation rasters for years ranging from 2021 to 2024.
2. Using the Extract by Mask tool, a tool that extracts the cells of a raster defined by the boundary of a mask, we created 4 new datasets for all four years that showed average annual precipitation within the boundaries of the Sonoran Desert Biosphere Region. The outer boundary of SDBR was used as a mask and the setting Extraction Area was set to Inside.
3. With our 4 new rasters, we wanted to find the average precipitation across our 4 year range. Using the Raster Calculator tool, we used the following calculation to find average precipitation: (Raster2021 + Raster2022 + Raster2023 + Raster2024) / 4. This produced our final raster that we titled Sonoran Desert Precipitation Model.
4. To apply a smoother gradient to our model, we used the Resample tool to decrease the cell size to 0.005 and settled Cubic Resampling Technique.
5. Symbology was applied to our raster using a Minimum Maximum Stretch type to highlight the significant differences between the arid desert landscape and the rainshadow effect seen on the mountains within Organ Pipe Cactus National Monument. A red to blue color scheme ramp was also used to further enforce these landscape precipitation differences.
6. Final raster layer was uploaded to ArcGIS Online and added to our StoryMap.

Partnership with the Tohono O'odham Nation

1. Imported the Federal American Indian Reservations dataset that was produced using National Geospatial Data Asset (NGDA) data from the U.S. Census Bureau.
2. Manually selected lands that were labelled as Tohono O'odham Nation. With features selected, a new dataset was exported as Tohono O'odham Nation.

3. Added Sonoran Desert Biosphere Region to highlight the shared boundary between the two lands. Changed symbology to show that each area was clearly defined for map users.
4. Final layers was uploaded to ArcGIS Online and added to our StoryMap

Transboundary Cooperation

1. Imported Sonoran Desert Biosphere Region's Area of Cooperation and Partnership layer into ArcGIS.
2. Using the editing tools, we manually digitized the El Pinacate Biosphere based on the boundaries defined on ESRI's World Imagery basemap. Changed symbology to show that each biosphere's boundary was clearly defined for map users.
3. Final layer was uploaded to ArcGIS Online and added to our StoryMap

Mammoth Cave Biosphere Region

Shaped by Water: Karst Landscape and Sinkholes

1. Imported karst potential map and sinkhole data from Barren River Area Development District (BRADD) ArcGIS Hub page in ArcGIS Pro.
2. Import Mammoth Cave Biosphere Region's outer boundary layer into ArcGIS Pro.
3. Using the Clip geoprocessing tool and the outer boundary of the Mammoth Cave Biosphere, we excluded the karst landscape and sinkholes that existed outside the Mammoth Cave Biosphere Region. The new feature classes were called KarstPotential_Clip and sinkhole_Clip.
4. Symbology for Mammoth Cave Biosphere Region's outer boundary layer was changed to red to distinguish Biosphere Region with basemap.
5. Final layers were uploaded to ArcGIS Online and added to our StoryMap.

Groundwater: A Hidden and Vulnerable Resource

1. Imported Kentucky Groundwater Sensitivity Regions Map from Kentucky Government Maps Open Data Portal into ArcGIS Pro.
2. Added sinkhole_Clip feature class and Mammoth Cave Biosphere Region's outer boundary layer.
3. Using the Clip geoprocessing tool and the outer boundary of the Mammoth Cave Biosphere, we extracted groundwater sensitivity region that lays within Mammoth Cave Biosphere boundary. The new feature class was called Ky_Groundwater_Sensitiv_Clip.
4. Applied unique value symbology using the 'SENSITIVITY' field, and styled it with a continuous color scheme based on a linear algorithm, using tulip pink as the color gradient.
5. Symbology for sinkhole_Clip layer was changed to blue to visually distinguish it

from the groundwater sensitivity region layer.
6. Added Biosphere boundary layer and highlighted it in light gray.
7. Final layers were uploaded to ArcGIS Online and added to our StoryMap.

Hidden River Cave: From Toxic to Transformative

1. Created a new point feature class called Hiddenrivercave in ArcGIS Pro.
2. Navigate to the location of Hidden River Cave in the map and used the Create Features tool to add a point at the location.
3. Symbology for the layer was styled to a museum pushpin icon from ArcGIS symbology galley.
4. Final layer was uploaded to ArcGIS Online and added to our StoryMap.

Champlain-Adirondack Biosphere Region

Champlain-Adirondack Biosphere Network's (CABN) Connection to Water

1. Watershed basin data pulled from Natural Resources and Conservation Service and U.S. Geological Survey as WBD_02_HU2_Shape
    a. Clipped the nation-wide dataset to the Champlain-Adirondack Biosphere Boundary.
2. Selected Lake Champlain Basin and used the geoprocessing tool 'Copy Features' for extraction as a new feature class. We wanted to differentiate the basin as the heart of the Champlain-Adirondack Biosphere Region
    a. We consolidated the attribute table to just include:
        i. Source Data
        ii. Source Originator
        iii. Acres
        iv. Square Kilometers
        v. Hydrologic Unit Code
        vi. Name
    b. We made the Lake Champlain Water Basin a darker blue symbology for emphasis.
3. Using community-based observations from iNaturalist, a CSV was downloaded that included latitude and longitude, species name, and an image of the Zebra Mussel from 2014-2025.
4. Using the XY Table to Point, CSV latitude and longitude data was converted into a points layer titled XebraMussel_Observations.
    a. The pop-ups for these observations were:
        i. Date of Observation/Time of Observation
        ii. Date of Creation
        iii. iNaturalist URL

iv. Image URL
v. Latitude
vi. Longitude
vii. Scientific Name
viii. Common Name
ix. Taxon Name

b. BullKelp_Observation was then clipped to the biosphere boundary to illustrate how this is a unique problem in the Lake Champlain Basin.

5. Duplicated layer for dual symbology. One layer was an untouched points layer of all the Zebra Mussel observations within the biosphere. The other identical layer's symbology was adjusted to use 'Heat Map' symbology since ESRI automates the tool for you.
6. For the StoryMap, we have the heat map as the initial view so people can quickly identify the densest Zebra Mussel habitat spaces. As a map action, you can switch on the points layer with individual observations that have additional attribute information.

Hiking the Adirondacks

1. Searching on ArcGIS Online, our team found a Web Map for hiking in the Adirondack Mountains called 'Hiking the High Peaks.' This Web Map contained point feature classes for the High Peaks, Campsites, Lean-To's, Paved Parking Lots, and Unpaved Parking Lots. It also included a line feature class for the trails connecting the Adirondack High Peaks to each other and with parking lots.
    a. Since this was a general ArcGIS Online resource, we verified accuracy with existing maps from the Adirondack Park Agency and this Web Map was indeed usable.
2. We imported this public resource and adjusted symbology for greater distinction between spaces.
3. To allow StoryMap viewers to feel immersed in these mountains, we added an attribute field for photos and adjusted the pop-up order so when users click on each peak, they have a photo with a view of the summit.
    a. Procured photos for each summit from various copyright free locations. Photos were placed into a folder titled "Adirondack_Photos". Sources included New York Department of Environmental Communication, SEAS team members, and others.
    b. Used the "Enable Attachments" and "Add Attachments" geoprocessing tools on the 'High Peaks' points layer to let each peak's photo be viewed when clicking on individual points. With the photos now merged with the points layer, the original folder does not need to be stored within ArcGIS Online.

Wild Walk Trail

1. No GIS files could be found of The Wild Center's trails on their property so our team found a pdf on their website of their trails.
2. We georeferenced a pdf of their Wild Walk Trail and created a new line feature class called 'Wild_Center_Trails.' The only attribute field we added as the trail name.
    a. We drew two major trails: the Wild Walk and an accessible trail for those unable to traverse the Wild Walk. We differentiated their symbology
3. Created line feature class and differentiated between the Wild Walk Trail and a handicap accessible trail on the property.

Sustainable Agritourism in CABN

1. Created point feature class called 'Agritoursm' with the geolocated Cornell Cooperative Extension of Essex county headquarters and Shelburne Farms based on Google Maps coordinates.
2. To allow StoryMap viewers to view the respective locations, we added an attribute field for photos and adjusted the pop-up order so when users click on each peak, they have a photo with a view of the location.
    a. Procured photos for each space. Photos were placed into a folder titled "Agritourism_Photos." Screenshots were procured off of Google Maps.
    b. Used the "Enable Attachments" and "Add Attachments" geoprocessing tools on the 'Agritourism' points layer to let each location's photo be viewed when clicking on individual points. With the photos now merged with the points layer, the original folder does not need to be stored within ArcGIS Online.

USBN has been a close collaborator of The Center for Large Landscapes, a non-profit organization dedicated to developing policy, planning, and research to support community-based conservation efforts. After discussions with administrators and GIS specialists within the center, upon project completion, our team's geodatabase and StoryMap will be transferred to their ArcGIS Online Group to prevent future loss of these precious shapefiles.

You can find a link to our StoryMap here:
https://storymaps.arcgis.com/stories/713a327011a544dbb9404f2e3149e536

Chapter 5: Gender Inclusivity in the United States Biosphere Network

Gender equality is named as a global priority of UNESCO for the World Network of Biosphere Reserves as outlined in the MAB 2025 Strategic Action Plan. However, partners of the program have long expressed concerns about the exclusionary nature of the "Man and the Biosphere" name, especially in the context of this global priority. Renaming the program was raised as a point for discussion during surveys of the MAB member nation programs and at the 33rd - 36th sessions of the International Coordinating Council in 2021, 2022, 2023, and 2024. A final decision was reached at the July 2024 meeting of the ICC to retain the existing "Man and the Biosphere" name. There is documented disagreement among regional networks of the MAB program about retaining the name or what a suitable replacement would be, but as of June 2024, the majority opinion was to retain the existing name, with "Humanity and the Biosphere" as the most frequently cited alternative. It is important to note that the leading reason biospheres provided for retaining "Man and the Biosphere" is that the program's name is gender-neutral in their language and therefore is not an issue rather than an opposition to gender inclusivity.

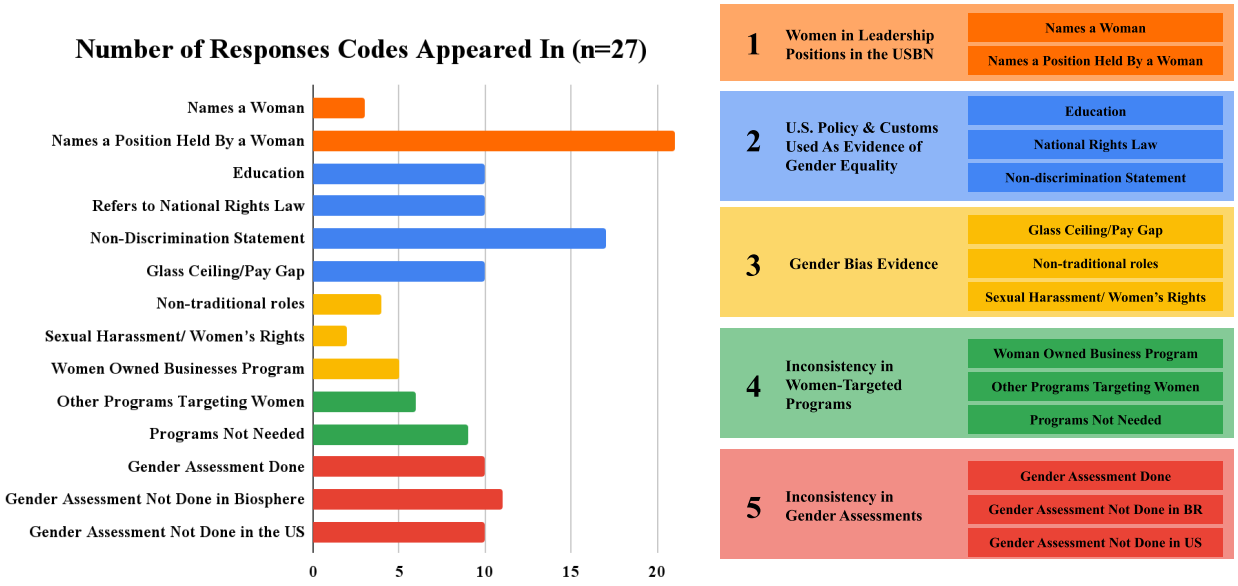
Gendered language does not just include terminology such as "woman" or "man" but also includes terminology considered generic that is actually based on a language's implicit agreement that the prototypical human being is male. These terms, masculine generics, include terms such as "mankind,""chairman," and even "humanity". Research has shown that their use "does not depict women and men as equal human beings," making gender minorities invisible rather than acting as an inclusive term (Menegatti & Rubini 2017). While gender-biased language contributes to discrimination and harmful stereotypes, gender-inclusive language has the opposite effect; people who hear and read gender-inclusive language "use them more themselves and, in turn, have more gender-balanced mental representations of social roles (Menegatti & Rubini 2017). Rather than just avoiding reinforcing traditional gender roles, gender-inclusive terms actually positively benefit gender equality.

An initial review of the guiding documents of the MAB program found that they follow UNESCO guidelines for gender inclusionary language, with the notable exception of the program's name. However, when the submitted periodic review documents of the United States Biosphere Network were reviewed, they displayed the use of gendered language excluding non-binary individuals as well as biased characterizations of women's roles within the organization. These documents, submitted every ten years to the ICC, include a targeted question about women's roles within the Biosphere.

> *2.4.4 Women's roles. Do women participate in community organizations and decision-making processes? Are their interests and needs given equal consideration within the biosphere reserve? What incentives or programmes are in place to encourage their representation and participation? (e.g. was a "gender impact*

assessment" carried out?) Are there any studies that examine a) whether men and women have different access to and control over sources of income and b) which sources of income do women control? If so, provide reference of these studies and/or a paper copy in an annex.

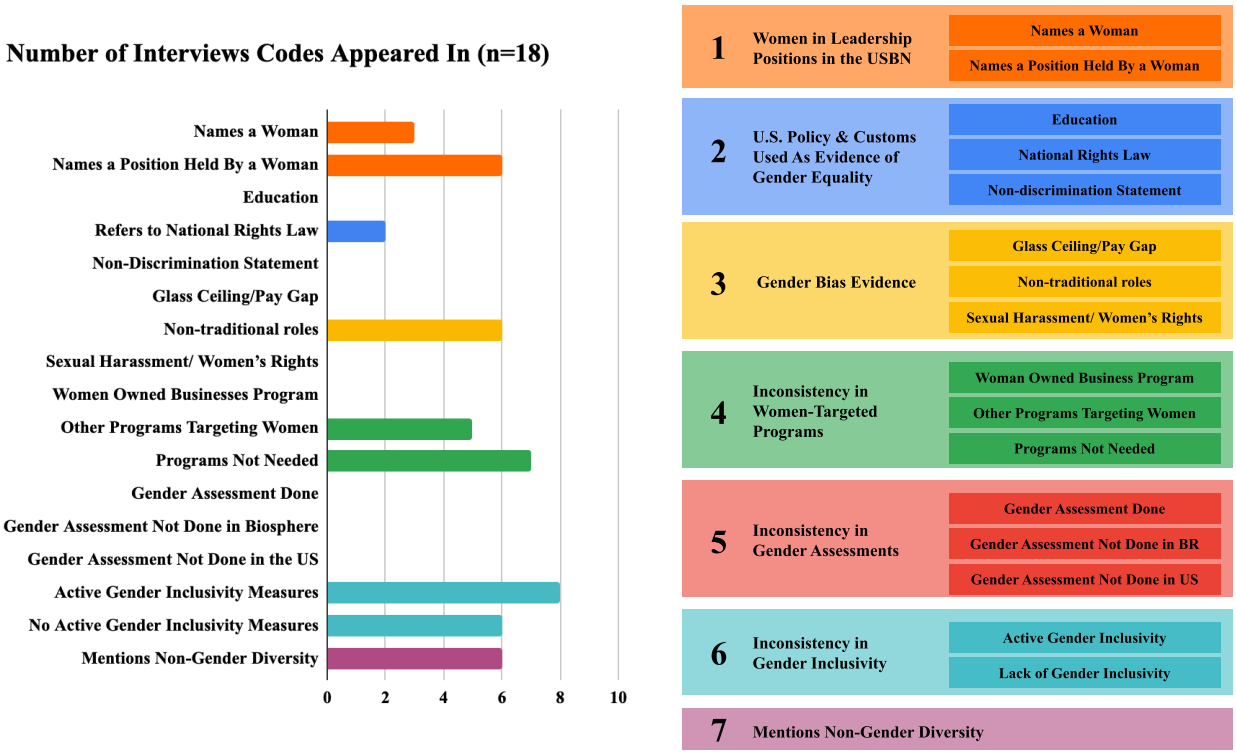
To determine the gender inclusivity of the U.S. Biosphere Network, a thematic analysis of responses using Braune & Clark's framework to the "women's role" question of the periodic review was conducted following the primary research question of "Are the United States biosphere regions gender-inclusive?" Fourteen initial codes were identified and grouped into



five encompassing themes. The analysis revealed a disconnect between the gender-inclusive language and ideals of founding documents and the periodic reviews submitted by the 28 US Biosphere reserves in the last round of review.

Figures 8a & 8b: A bar chart demonstrating the number of biosphere periodic review form responses in which each of the codes appeared. Colors align with the accompanying diagram, which shows the five encompassing themes of the 14 initial codes.

To assess more recent gender inclusivity in the regions, the gender team developed an interview question to be administered by the qualitative team as part of their interview process. The codes and emergent themes of the initial data set of periodic reviews were then compared with a thematic analysis of selected interviews conducted across the network. The thematic analysis of interview responses revealed different themes than the periodic reviews, with additional themes appearing and previous themes notably lacking from responses. In the interviews, respondents brought up additional aspects of diversity, not just gender, and spoke specifically about the presence or lack of gender inclusivity in their community. These themes indicate a lack of consistency in active gender inclusivity across the program and a



lack of understanding of what the periodic review form is asking. This provided the foundation for the recommendations of the report for the Network as a whole and the development of an instructional deliverable for biospheres.

Figures 9a & 9b: A bar chart demonstrating the number of interview responses in which each of the codes appeared. Colors align with the accompanying diagram, which shows the seven encompassing themes of the 17 total codes.

Predominantly, this research revealed inconsistency in how gender inclusivity is understood and acted upon within the United States Biosphere Network. A further key finding of this research is the difficulty of interpreting the international periodic review form's question on gender roles for national institutions in light of the difference in cultural norms and practices surrounding gender diversity across the World Network of Biosphere Reserves. Even a comparison with a similar gender inclusivity research publication from Canada revealed differences in how inclusivity is assessed and supported in their Biosphere network. It is not feasible to expect an international form to adapt to each countries cultural norms surrounding gender inclusivity terminology, it is the responsibility of the individual biospheres to interpret these international forms, in line with the shared values of their community and national network. Towards this end, a sub-deliverable of the gender inclusivity work was a one-page guide for U.S. biospheres on how to interpret and answer the '2.4.4 Women's Roles' question

of the periodic review, along with recommendations to use the question as a moment of reflection into their organization's gender inclusivity at large.

Recommendations

This research has culminated in four key recommendations for the United States Biosphere Network:

1. Conduct informal gender assessments of biospheres & partners, evaluating:
    a. The distribution of leadership positions to gender minorities;
    b. The inclusivity of language used in both internal and external communications;
    c. Existing and potential future programming to enhance gender inclusivity.
2. Include provisions for inclusivity in biosphere strategic work plans.
3. Refer to "Interpreting Question 2.4.4" resource as periodic reviews are completed.
4. Continue to demonstrate support for changing the gender-biased name of the UNESCO MAB program.

The full research paper discusses the impact of gender-inclusive language and the state of the US Biosphere Network's gender inclusivity, then proposes feasible, timely interventions for the Network to improve inclusivity and support mindful completion of the upcoming cycle of periodic reviews.

Link to Full Paper

Chapter 6: Building Climate Resilience in the United States Biosphere Network

The final deliverable and key action of this capstone project was fostering communication and collaboration on climate-related work in the United States Biosphere Network (USBN). In the summer of 2024, Alaina partnered with the Stewardship Network, funded by the Weinberg Internship, to research climate actions across the USBN. In July, Alaina and fellow team member Sam attended the Staying Connected Initiative's Northeastern North America/Turtle Island Landscape Connectivity Summit to represent the USBN and promote collaboration between American biospheres and their neighbors to the North. Alaina's research, led by advisor Cliff McCreedy, has culminated in a report called "Building Climate Resilience."

Climate change is already affecting every biosphere, every community, and every partner in the USBN and the Man and the Biosphere (MAB) programme worldwide. There are high-visibility effects with extreme weather events and record temperatures as well as long-term, low-visibility effects only conservation professionals see. "Building Climate Resistance" details projects and actions across the USBN that increase the climate resilience of their regions. The purpose of this report is to promote excellence, share expertise, and encourage further efforts for strong, healthy communities.

While there are fantastic efforts happening across the network to predict and respond to the effects of climate change in the fields of conservation and restoration, those are not the programs that were highlighted in this report. The wealth of the Biosphere program is its ability to look beyond protecting ecosystems to include socio-ecological dimensions in the response to climate change.

> *"A sole focus on biodiversity conservation will undermine the added value of the MAB Programme and the biosphere reserve designation to the detriment of local communities and the planet at large."*
>
> *- Technical Guidelines, 15*

In the report are community programs, tools, and models designed to be utilized at the local and regional level, and beyond. By focusing on climate resilience work in the United States Biosphere Network that embodies all three functions of a biosphere region, the report hopes to demonstrate the value of the Biosphere program as we share expertise and encourage further efforts for strong, healthy communities. Connecting climate-related research teams improves collaboration by facilitating the exchange of diverse ideas and resources, strengthening the United States Biosphere Network's ability to address complex environmental challenges more effectively and leveraging the USBN's value as a network of varied partners.

Already, the “Building Climate Resilience” report has acted as a tool for communication and collaboration within the United States Biosphere Network as well as with international Biospheres.

Building Climate Resilience Report Contents:
Link to Full Report

Climate Atlases

University of Tennessee Knox Socio-Ecological Vulnerability Atlas
Southern Appalachian Biosphere Region

Developed by the University of Tennessee, this ESRI-based atlas visualizes how socio-economic and environmental variables interact to affect vulnerability, providing local decision-makers with targeted reports to guide climate adaptation.

CABN/FABN Atlas of Climate and Environmental Change
Champlain Adirondack Biosphere Network and Frontenac Arch Biosphere Network

Created by a team at SUNY-ESF, this open-access atlas supports transboundary climate planning, engaging local communities through workshops and deep mapping to ensure inclusive, data-driven climate resilience strategies.

Coastal Resilience

Coastal Resilience Project Map
Obtawaing Biosphere Region

A collaboration with the Great Lakes Commission, this mapper catalogs over 40 coastal projects since 2010, providing tools and data to prioritize and inspire future restoration and conservation work across the region.

Coastal Resilience Tool on Virginia’s Eastern Shore
Virginia Coast Biosphere Region

Led by The Nature Conservancy, this community-informed tool forecasts flood and sea level risks while identifying opportunities for nature-based shoreline restoration on Virginia’s Eastern Shore.

Vulnerability Assessment

Climate Change Vulnerability Assessment
Golden Gate Biosphere Network

In partnership with EcoAdapt, this assessment evaluates 21 species and habitats in the San Francisco Bay Area, identifying major stressors and adaptation strategies to guide integrated terrestrial and marine climate planning.

Producing Changemakers

Wild Center Youth Climate Summits
Champlain Adirondack Biosphere Network

This youth-led summit series empowers high school students to design and implement community-specific climate action plans, with a model that's been replicated nationally and internationally.

Resources

Climate Change Resources Toolkit
Obtawaing Biosphere Region

A comprehensive toolkit offering city planners case studies, adaptation guides, and region-specific resources on climate justice, tribal knowledge, and coastal resilience.

United States Climate Resilience Toolkit

A centralized federal platform providing tools, datasets, and expertise to help individuals and communities plan for climate resilience across sectors.

National Park Climate Future Summaries

Summaries from the National Park Service that provide climate exposure data for U.S. parks to support vulnerability assessments and adaptation strategies, especially useful for biospheres centered on national parks.

Resist-Accept-Direct Framework

A strategic model for resource managers to choose whether to resist, accept, or direct ecological changes driven by climate shifts, offering clarity on long-term adaptation outcomes.

Chapter 7: Conclusions and Future Directions

The SEAS USBN Masters Team is incredibly proud of the work we accomplished in our sixteen month tenure with our clients and advisor.

The USBN Qualitative Research Team's investigation into the connectivity and challenges within the United States Biosphere Network has revealed crucial insights into the operational barriers, collaboration gaps, and best practices among Biosphere Regions. This study emphasized the importance of viewing the network as a "network of networks" and highlighted the necessity for improved strategic alignment within the United States Biosphere Network for its long-term sustainability. Although local collaboration with stakeholders is widely practiced, the USBN can advance its mission by fostering increased inter-region collaboration, aligning organizational capacity to enhance resiliency, and transitioning from traditional park-centric models to community-driven approaches. The research underscores the valuable insights gained through semi-structured interviews and community observations, resulting in strategic recommendations to strengthen the Network's mission in sustainable development. The team also prepared detailed case studies showcasing successful practices that align with the UNESCO Man and the Biosphere (MAB) program's goals, offering a roadmap for broader adoption across the network.

The MAB Biosphere Programme began from a desire to formalize research into the relationship between people and nature on an international scale. The research projects of this Capstone built upon this proud tradition of research, using the biosphere program itself as the research subject. The gender inclusivity research highlighted institutional inconsistencies among the global and regional goals of biospheres in regard to gender inclusivity, providing valuable and actionable recommendations to the Network. "Building Climate Resilience" has become a useful tool of communication and collaboration, recognizing the unique power of the USBN to further action on climate change in the U.S. biospheres.

The creation of the shapefile geodatabase with each of the properly zoned biospheres removed a large hurdle for USBN in the 2026 and 2027 Periodic Review process. In the last 2016 review, this process was arduous for USBN organizers and biosphere regions alike. We hope that this solid foundation of geospatial data management catalyzes biospheres to create innovative sustainable solutions. With the creation of the StoryMap, USBN now has a central location to send biospheres and the public alike. This asset is a great communication tool and fills a key gap in their toolkit that conveys the range and breadth of work under the network's care.

The deliverables that the GIS, Qualitative, and Research teams created for USBN shows the potential that biospheres can have on world health, equity, conservation, and well-being. We hope these deliverables create a positive feedback loop for communications and involvement throughout the network. With the number of interviews and interactions we had across USBN throughout this process, we found incredibly compassionate, collaborative, and kind people. It shows that the more varied USBN can be and who their partners are, the

more resilient and inclusive they can be both bottom-up and top-down. With deliverables like the StoryMap and Climate Report, our work can invigorate dormant biospheres to become active and engaged members

Despite the tumult of world politics and the United State's seesawing relationship with UNESCO, USBN perseveres and with our StoryMap, they now have a unifying and immersive online resource for people to learn about all things USBN.

We hope that SEAS and USBN continue to have fruitful relationships and that this innovative UNESCO designation and concept progress to the potential this masters team believes it is capable of.

Appendices

Appendix A: Pilot Interview Guide

I am part of a team of master's students from the University of Michigan working with the US Biosphere Network over the next year to develop a guiding framework for developing the activities of the individual Biospheres and the network as a whole for the USBN to use going forward. The goal of this set of interviews is to identify broadly some key value propositions and relationships of the Biosphere Network that our team can dive into more closely for our summer research. For this interview I want to start out by getting a better sense of your role and involvement in the biosphere network...

1. How did you first hear about the Biosphere Network?
2. What about the USBN and the larger Man and the Biosphere Network excited you the most?
3. How did that lead to you getting involved?

These next few questions are dealing with the overall value narrative of the network so more network focused, but I would love to get your unique point of view on the subject.

Narratives

2. In your own words, what is the goal of a Biosphere Reserve?
    1. What aspects of the Biosphere mission do you feel connect the most to the public?
3. In what ways have you seen your community's/partner's understanding of the goals of a Biosphere differ from the official UNESCO guidelines? (For steering committee members)
4. From the perspective of a community member in the biosphere region, how would you say living/working in a BR alters their day-to-day experiences?
    1. Would most community members know of the existence of the BR?

*Now you are involved in the Biosphere by (answer to 1st question…)*hearing what people are really excited about helps shed light on what they value. I'm curious what you're particularly excited about regarding your organization's partnership with the biosphere network?

Key Actors/ Current relationships

4. Can you tell me about your organization's partnership with the Biosphere Network?
    1. When did the partnership begin?
    2. Who was involved in this process?
    3. What are some ways the partnership with the biosphere enriches the National (partnership organization)?
    4. What are some ways the partnership with the (partner organization) enriches the Biosphere Network?

5. Are there any ways in which you feel the partnership could improve?
6. Can you tell me about one partnership with any of the Biospheres in the Network, or the network as a whole you are particularly excited about?
7. What are some ways the partnership with the partner just mentioned enriches the biosphere or network?
8. Are there any ways in which you feel the partnership could improve?
9. In what ways do you see this partnership evolving in the future?
10. Can you think of any groups you would be excited about building a partnership with, but have not yet begun? (Why?)

5. What are some key actor groups within the area serviced by the Network that you would like the reserve to partner with more closely?
    1. What reasons do you feel they have not engaged up to this point?
    2. What are some ways the biosphere could strengthen that relationship?

Potential Interview Design

6. Based on our discussion and your own experiences, who are some people or groups that should be included in a larger assessment of biosphere partnerships?

Appendix B: Final Interview Guide

Summer Research Questions:

I am part of a team of master's students from the University of Michigan working with the US Biosphere Network over the next year to develop a guiding framework for developing the activities of the individual Biospheres and the network as a whole for the USBN to use going forward. The goal of this set of interviews is to gauge the current needs and abilities of both the Biosphere Regions and the communities they serve. For this interview I want to start out by getting a better sense of your role and involvement with the biosphere, if any, and then based on that a casual discussion about the Biosphere's mission and how it can support your own individual or organizational needs and goals.

Current Partners:

1. How did you first hear about (the local) Biosphere Region?
2. What about the Region and the larger US Biosphere Network excited you the most?
3. What has been the highlight of your experience at (local BR) so far?
    a. What has been the hardest part of your experience so far?
    b. What changes, if any would you like to see
4. Can you tell me about your organization's partnership with (the local) Biosphere Region?
    a. When did the partnership begin?
    b. Who was involved in this process?
    c. What are some ways the partnership with the biosphere enriches (the partner organization)?
    d. What are some ways the partnership with (the partner organization) enriches the Biosphere Network?
    e. Are there any ways in which you feel the partnership could improve? (IF new, how would you like to see this partnership grow?)

Biosphere Staff:

Same as above but switch question 4 with:

4. Can you tell me about your organization's partnerships?
    a. When did the partnership begin?
    b. Who was involved in this process?
    c. What are some ways the partnership with the biosphere enriches (the partner organization)?
    d. What are some ways the partnership with (the partner organization) enriches the Biosphere Network?
    e. Are there any ways in which you feel the partnership could improve?

f. Can you think of any groups you would be excited about building a partnership with, but have not yet begun? (Why?)

Community Members - what value does the Biosphere add? (questions for people who might not know what a BR is)

I am part of a team of master's students from the University of Michigan working with the US Biosphere Network over the next year to develop a guiding framework for developing the activities of the individual Biospheres and the network as a whole for the USBN to use going forward. The goal of this set of interviews is to gauge the current needs and abilities of both the Biosphere Regions and the communities they serve. For this interview, I would like to begin by getting a sense of your current knowledge about the local Biosphere region and your own experiences with the landscape, then we will move into some value based questions to end out. Before we begin, I want to make it clear that there are no right or wrong answers. We want and value your real thoughts and unique experience.

5. Are you familiar with (local BR)?
    a. If yes: What have you heard about it? Or What was that experience like?
        i. "What specific benefits or negatives have you experienced from living within or near a biosphere–if any?"
    b. If no (and realistically even if yes: give a quick overview of what a Biosphere is and what region their local one covers. ["Three key aspects - conservation, sustainable economic development, and community education and engagement"].
    c. What are your initial reactions to the mission of a Biosphere Region?

6. (Pick up here for Partner and Staff interviews) How would you describe your relationship to this land (*referring to the local BR*)?
    a. How do *you* interact with it?
    b. How do you mainly see *others* interacting with it?
    c. Can you tell me about a natural area (locally–if the person is local) you feel the most connected to?

7. Are you aware of any conservation actions taking place in this vicinity?
    a. If yes, what do you think about them?
    b. Do you feel they have been helpful? Why or why not?

8. Are you aware of any sustainable development actions taking place in this region?
    a. If yes, what do you think about them?
    b. Do you feel they have been helpful? Why or why not?

9. Is your community actively promoting gender inclusivity?
    a. If yes, do you feel they have been helpful? Why or why not?

Thank you for sharing your experiences and knowledge with me. We are going to shift now to some more open questions about the needs of yourself and your community. Once again, there are no right or wrong answers, and feel free to share only as much as you are comfortable with

10. In your opinion, what are some of the needs of your community?
    a. Based on the needs you identified, which aspects, if any, of the mission of Biospheres sound the most useful for your community? (be prepared with the same 1 sentence overview as above if needed)

11. In your idea of a perfect world, what would your community look like in ten years–what would change, and how so?

Reserve a solid chunk of time for these next two questions as they can lead into much longer responses than you are expecting

12. Is there anyone who is not currently involved in the Biosphere process and should be?

13. Is there anything we haven't touched on yet, you feel it is important for me to know?

Appendix C: Codebook

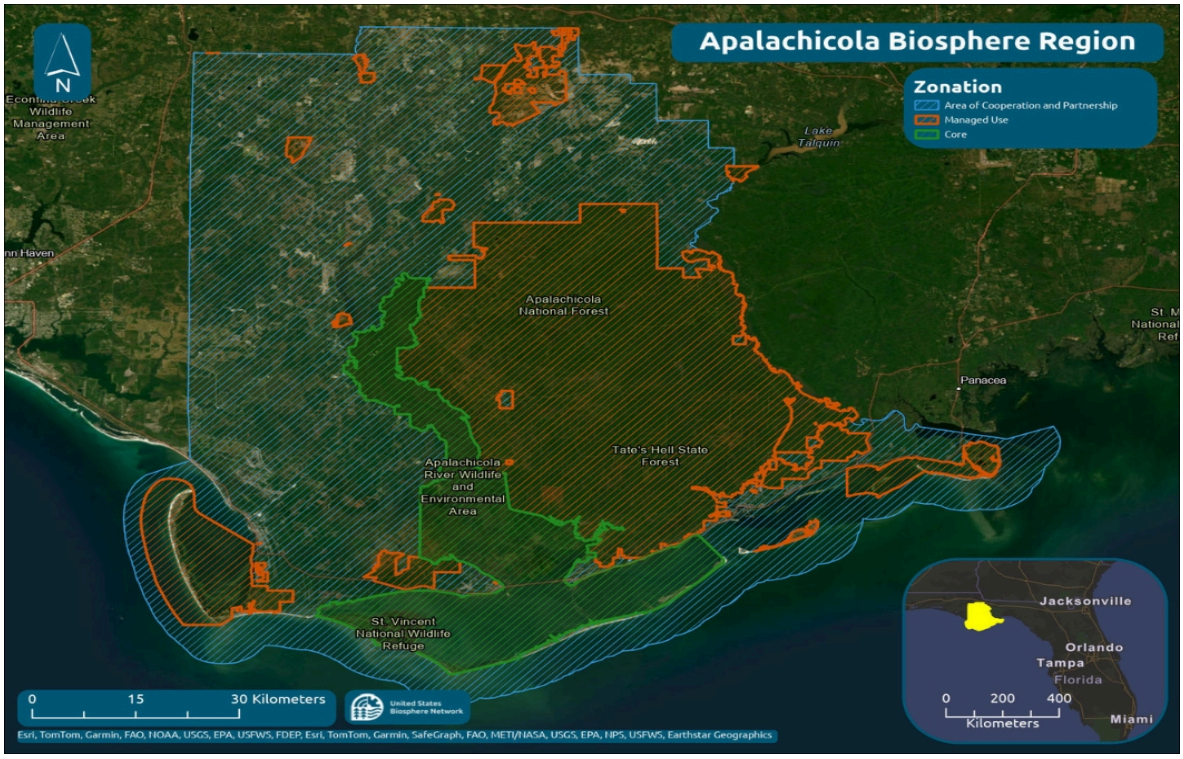
Level 1 Codes	Level 2 Codes	Description
Stability	Funding L	Funding length and longevity for growth
	Turnover	Movement of
	Knowledge Loss	Loss of information related to the BR over time
Capacity	Funding av	Current operational funding
	Time	Time availability or constraints for pursuing Biosphere actions
	Manpower	Work availability or constraints for pursuing Biosphere actions
Community	Acceptance	Positive reactions to Biosphere actions
	Awareness	General awareness and knowledge about biosphere actions
Core Mission	Conservation	Conservation as a tenant of the MAB program
	Sustainable development	sustainable development as a tenant of the MAB program
	Community building	community engagement as a tenant of the MAB program
	Core conflict	Friction arising in the implementation of the 3 core missions
Value	community > biosphere	what value do the community and partner(s) have for the biosphere
	biosphere > community	what value does the biosphere have for the community
	Value general	general value of biospheres for society
Network	value of N	what value does the network framework have for the individual biospheres and growth of the program
	building	ways to build and develop the network framework for the US biosphere program
	communication	how is information shared and communicated through the network
Challenges	uninvolved groups	identified groups that have for various reasons not engaged with the biospheres
	Tribal Engagement	Challenges in engaging with Tribal Communities
	Misc	General challenges

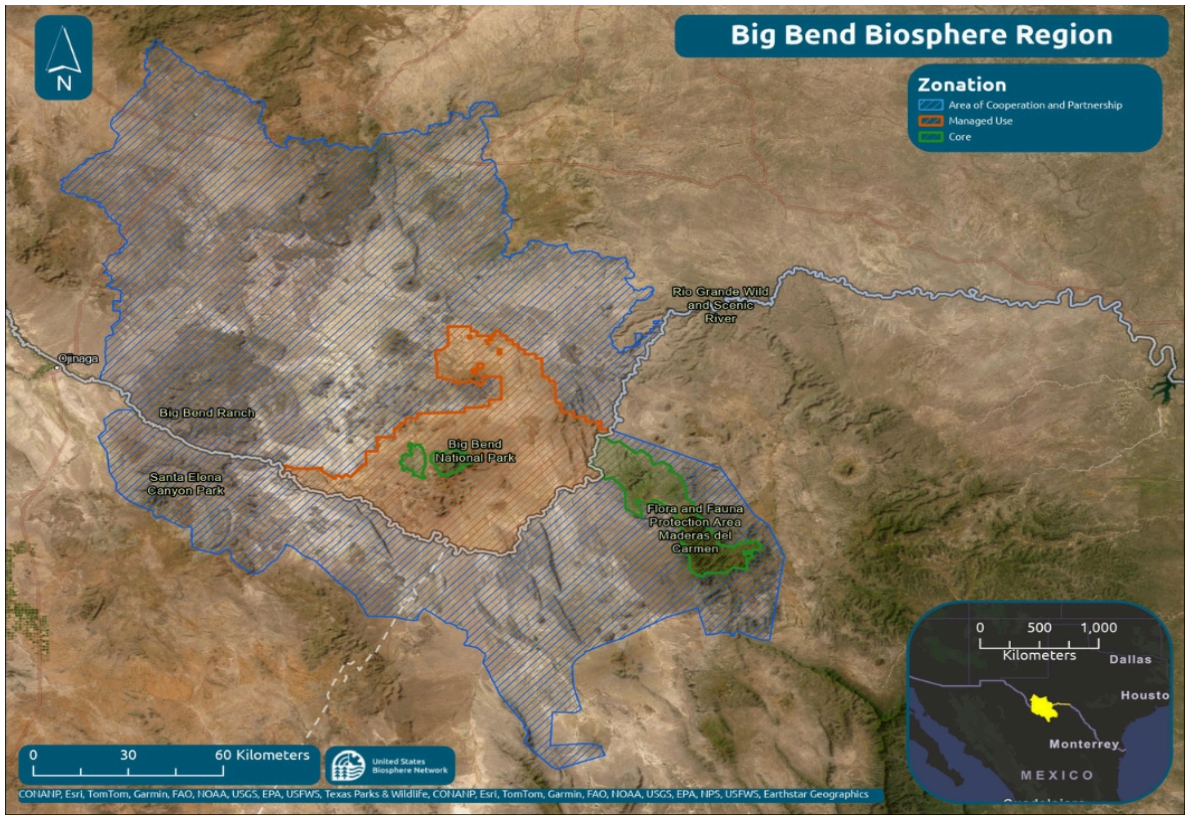
Appendix D: Key Actor Groups

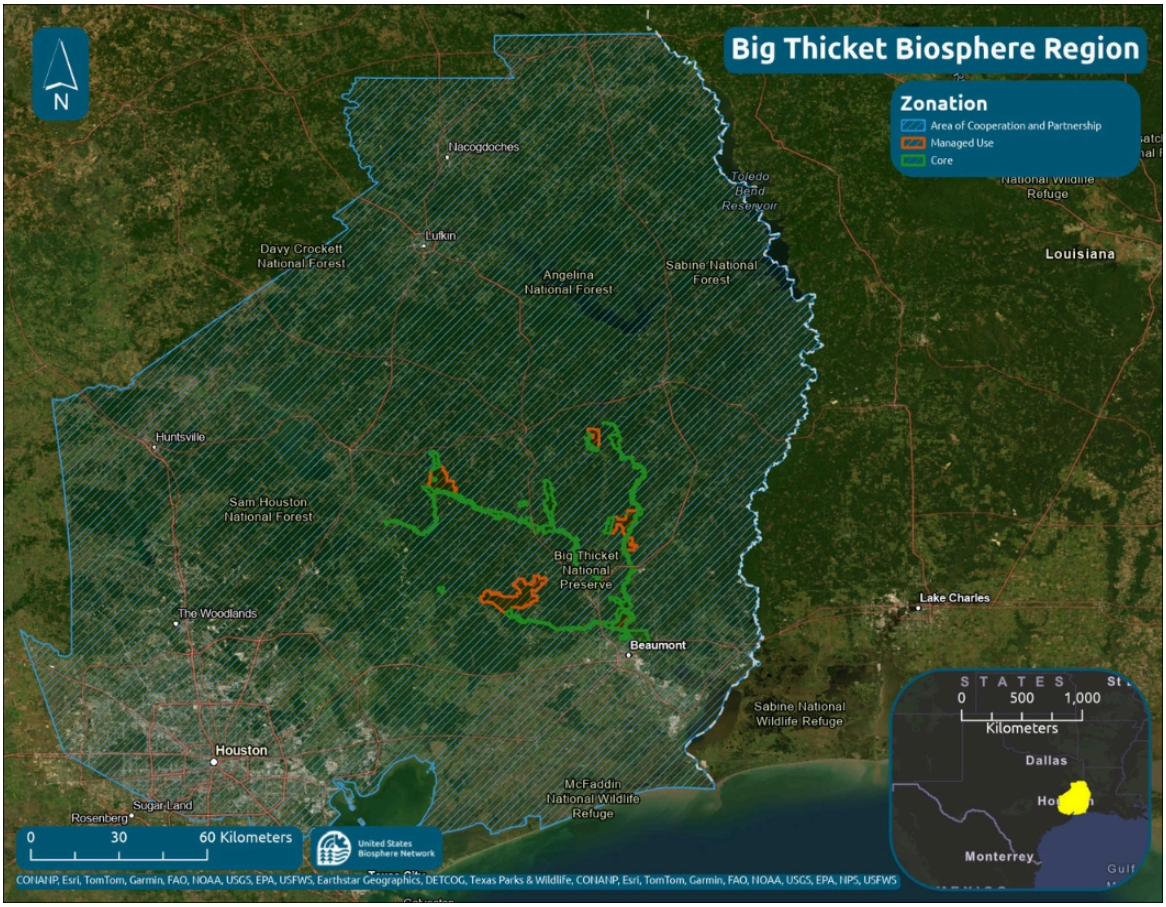
Actor Groups	Examples	Opportunities	Barriers
Federal Agencies	NPS, NFS, NOAA, CLLC, BLM	Funding, legitimacy, research and conservation experience	Already partnered in some areas, can be overwhelming application process for understaffed regions
Local government	City councils, county commissioners	"Control over land use"	Change from town to town/county to county, what value does the Biosphere have for their community?
Education	Universities- research, local k-12 schools, outreach centers	Universities: Research capacity, scientific expertise K-12 schools: toehold in community	In most cases outsiders in communities, quick turnover of research teams, distrust of academics in some communities
NGOs	Anza Brega Foundation, Southeast Rural Community Outreach Organization	"an NGO can do things that a federal or state or local government can't do"	NGOs at different sizes can have fluctuating capacity and funding
Indigenous Communities*	*Along with other marginalized communities	TEK, pre existing relationship with the land, build community capacity through connections and development goals	Broken trust with outside researchers and federal conservation entities, variety of tribes with individual needs in each Biosphere
Business	Local Chambers of Commerce, ecotourism	Sustainable development is one of MAB core tenants, ecotourism is a key component of some of the local communities already	Often looking for demonstrated financial gain, harder for small local businesses to take risks
Agriculture	Local farmers & ranchers, focus on sustainable practices	"But you know, one thing that's, that fits with the biosphere mission is access to local foods. And farm to table. Right. So that's a niche, I think we could explore more also crop wild relatives and crop genetic diversity"	Tensions between many in the agriculture sphere and federal/international land management organizations
Youth	USBN youth boards, fellow graduate researchers, k-12 school children	"the dinner table. One of the greatest places to exchange information. So the kids in our in our K through eight classes, go home and tell mom and dad about this at dinner tonight.	Quick turnover of youth interns and researchers, younger children have less agency about daily activities

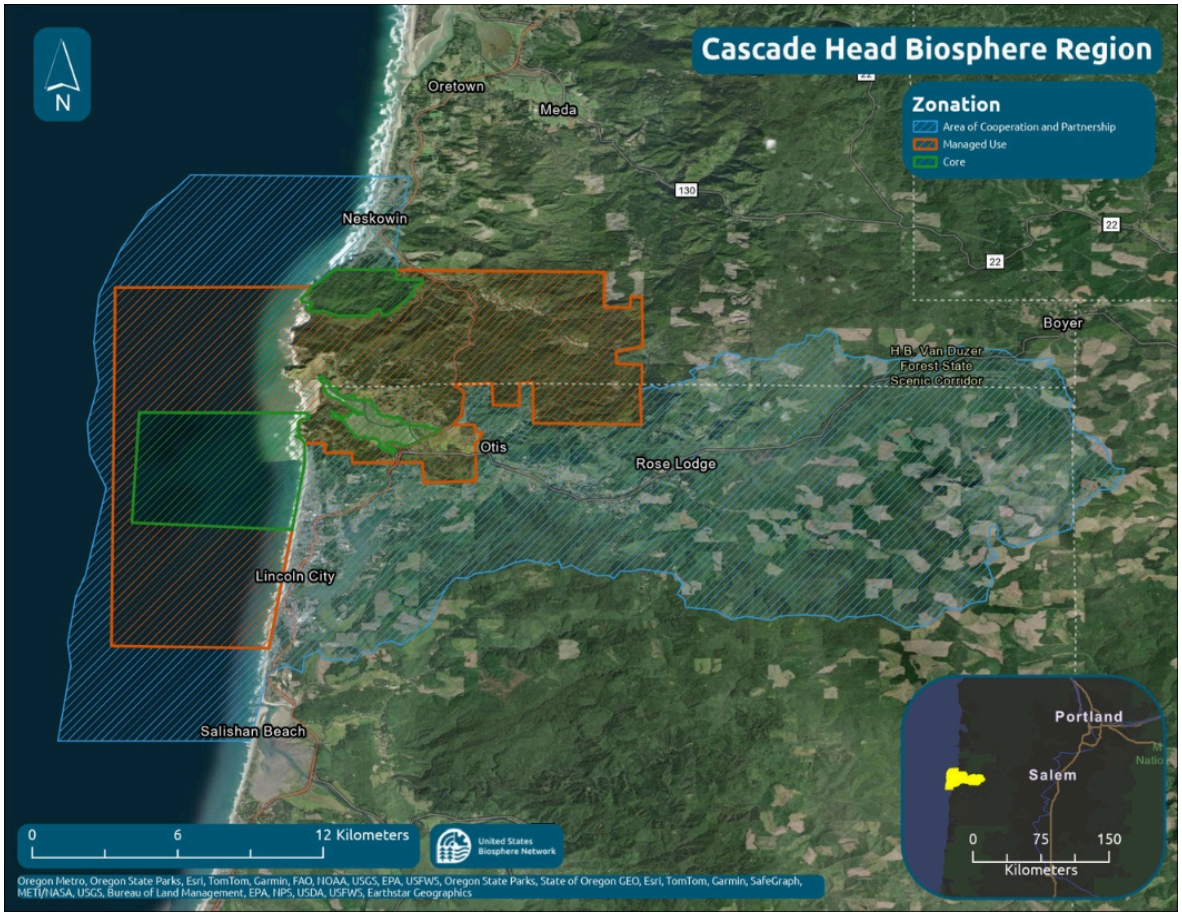
Appendix E: Formalized Biosphere Zonation Maps

Figures 10a and 10b: Apalachicola and Big Bend Biosphere Regions Zonation Maps

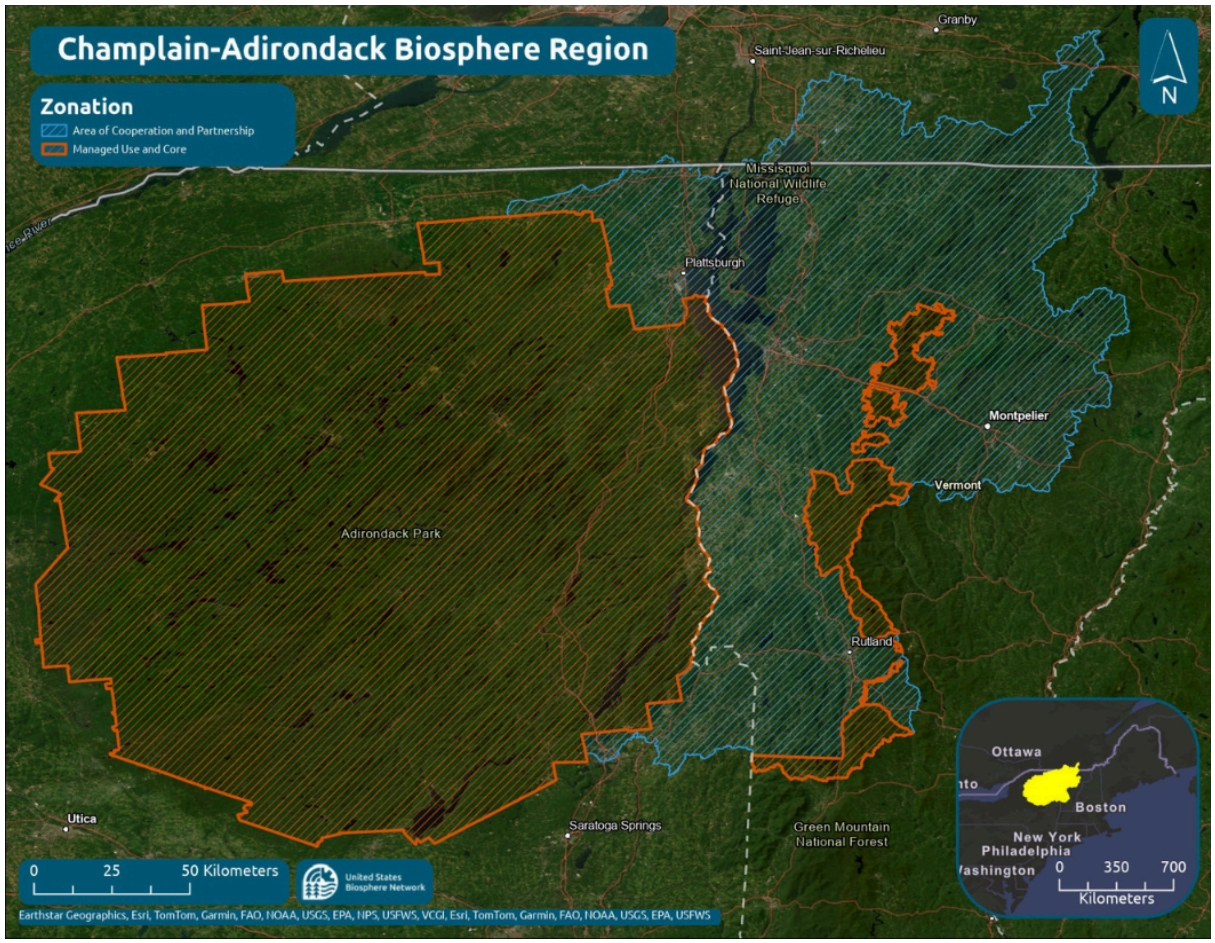


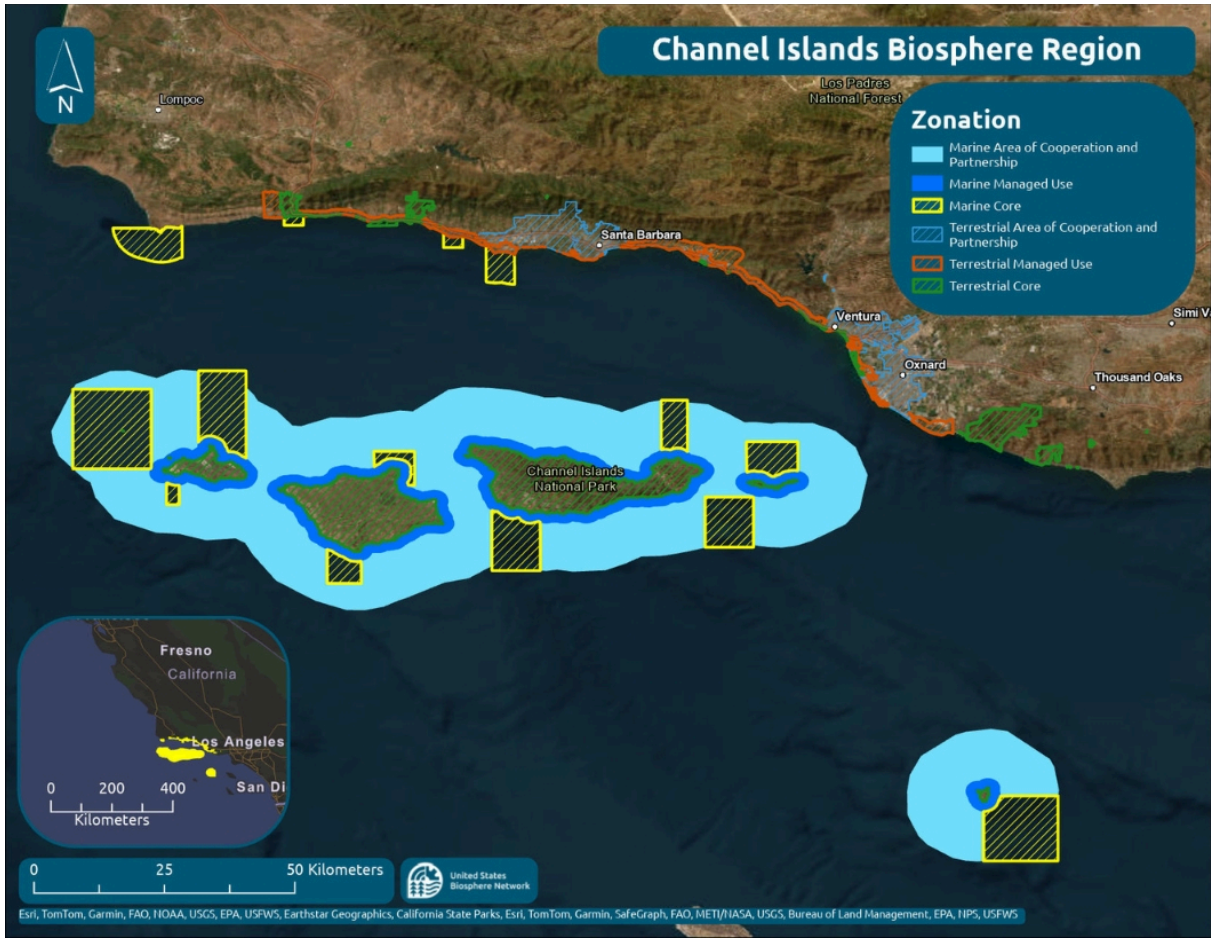




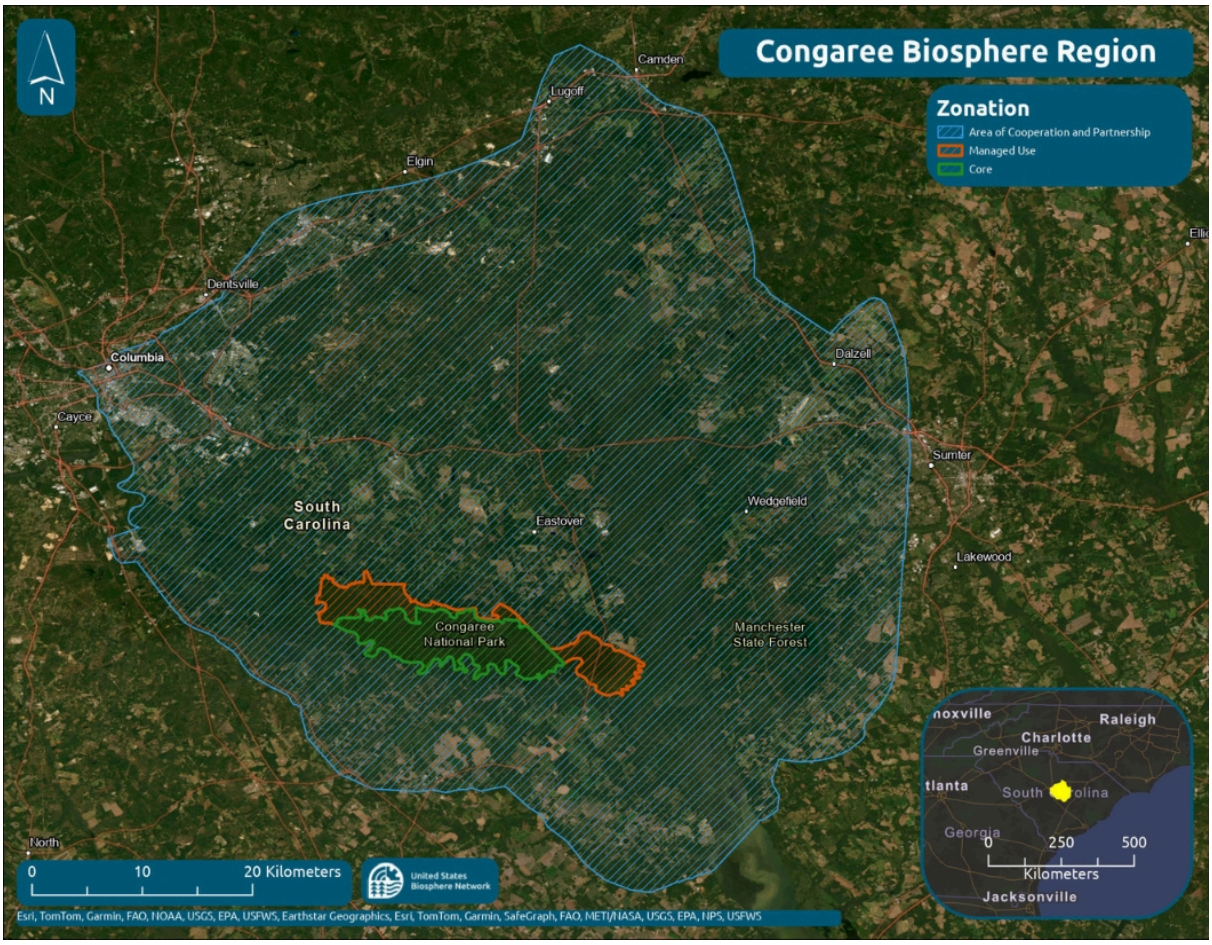


Figures 11a & 11b: Big Bend and Cascade Head Biosphere Regions Zonation Maps





Figures 12a & 12b: Champlain-Adirondack and Channel Islands Biosphere Regions Zonation Maps



Figures 13a & 13b: Congaree and Crown of the Continent Biosphere Regions Zonation

Maps

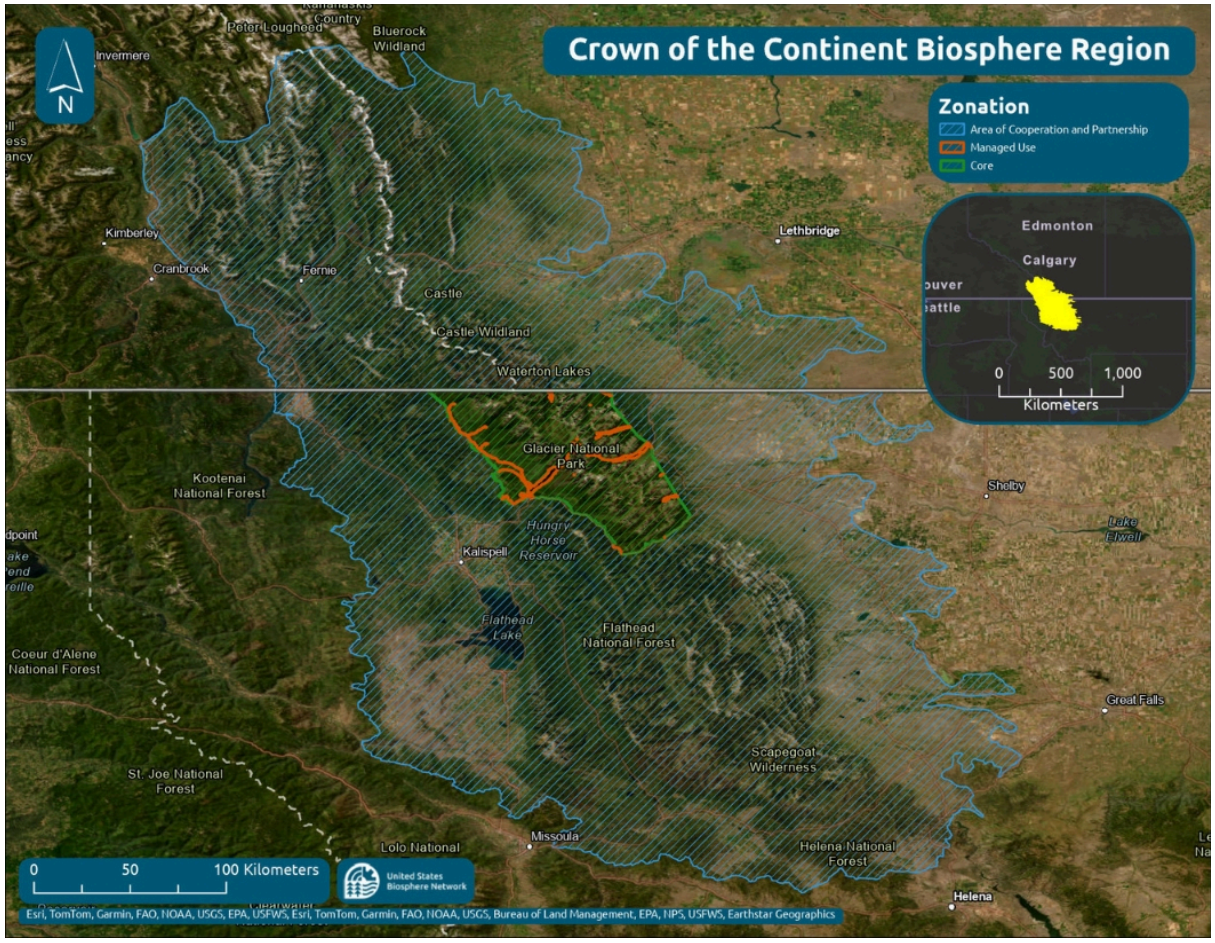
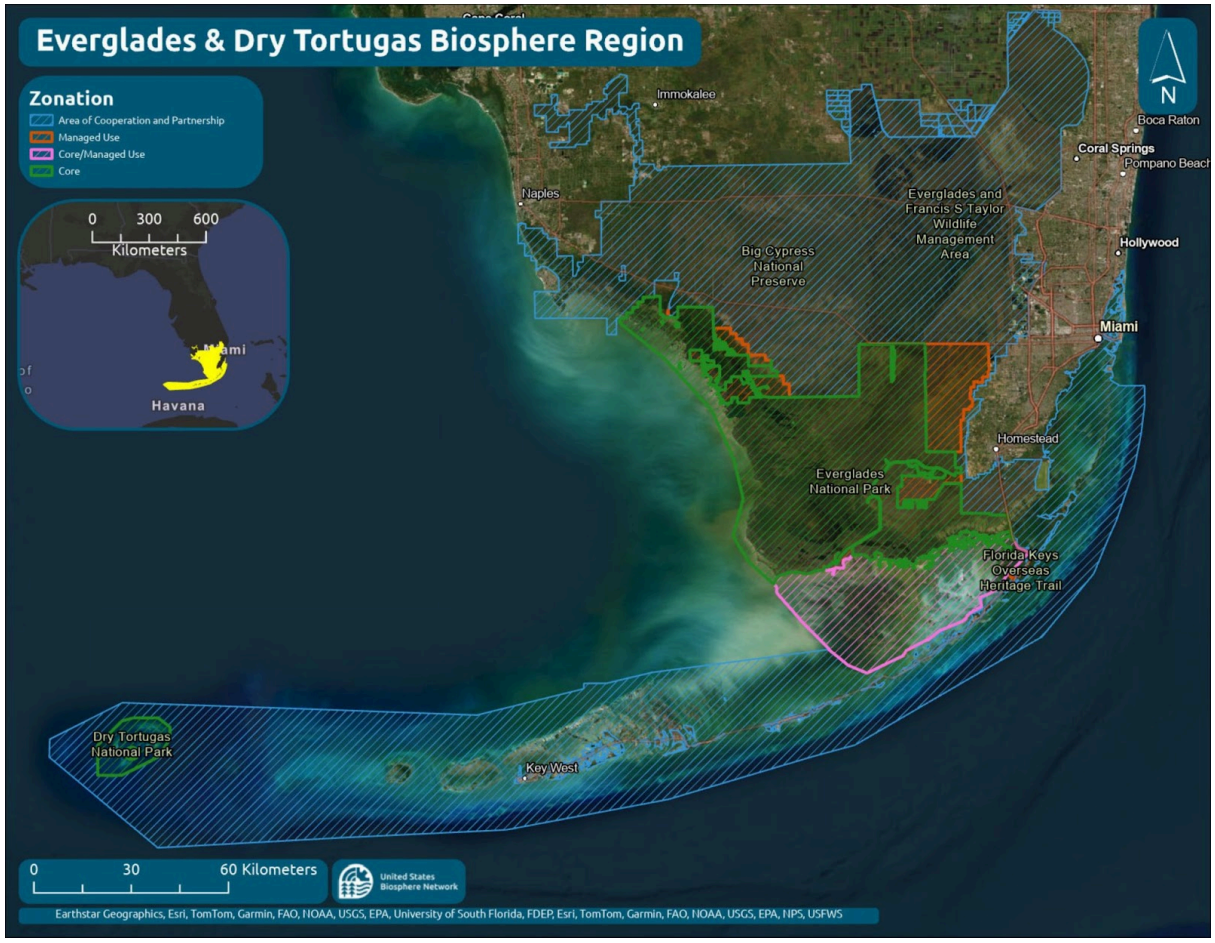
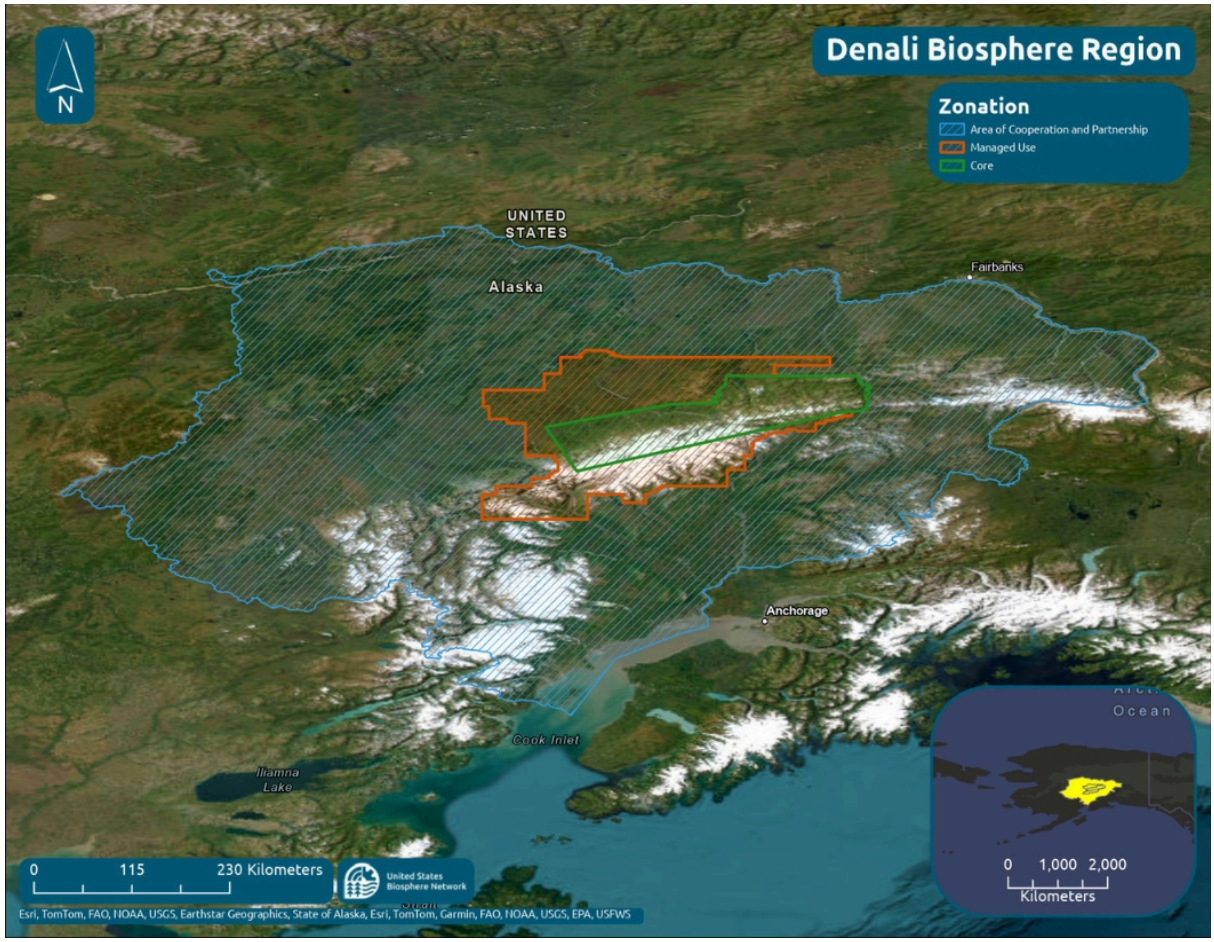
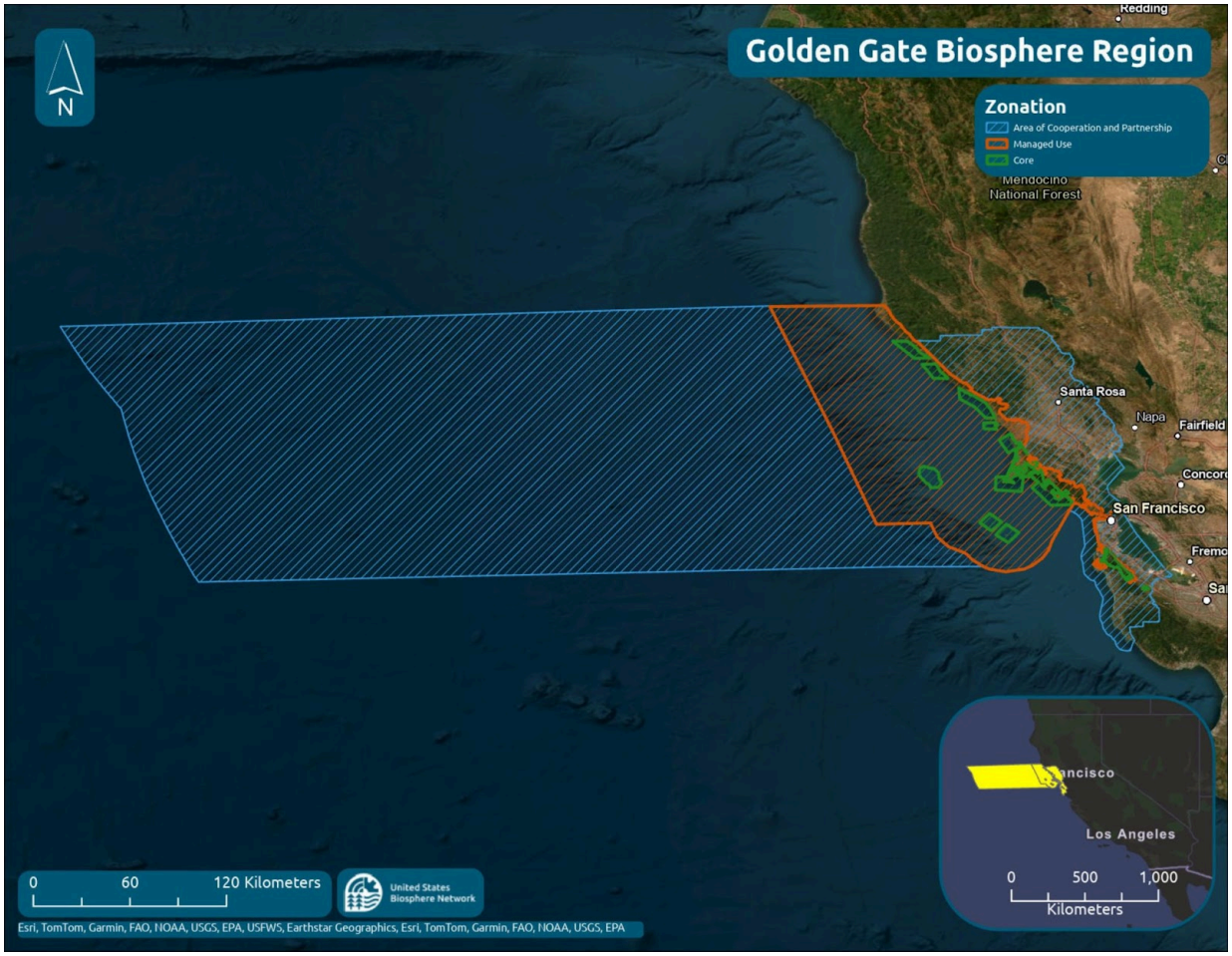

Crown of the Continent Biosphere Region
Zonation
Area of Cooperation and Partnership
Managed Use
Core
Edmonton
Calgary
0 500 1,000
Kilometers
N
Invermere
Peter Lougheed
Country
Bluerock
Wildland
Kimberley
Cranbrook
Fernie
Castle
Castle Wildland
Waterton Lakes
Lethbridge
Glacier National
Park
Kootenai
National Forest
Hungry
Horse
Reservoir
Kalispell
Flathead
Lake
Flathead
National Forest
Coeur d'Alene
National Forest
St. Joe National
Forest
Lolo National
Missoula
Scapegoat
Wilderness
Helena National
Forest
Helena
Great Falls
Shelby
Lake
Elwell
0 50 100 Kilometers
United States
Biosphere Network
Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS, Esri, TomTom, Garmin, FAO, NOAA, USGS, Bureau of Land Management, EPA, NPS, USFWS, Earthstar Geographics

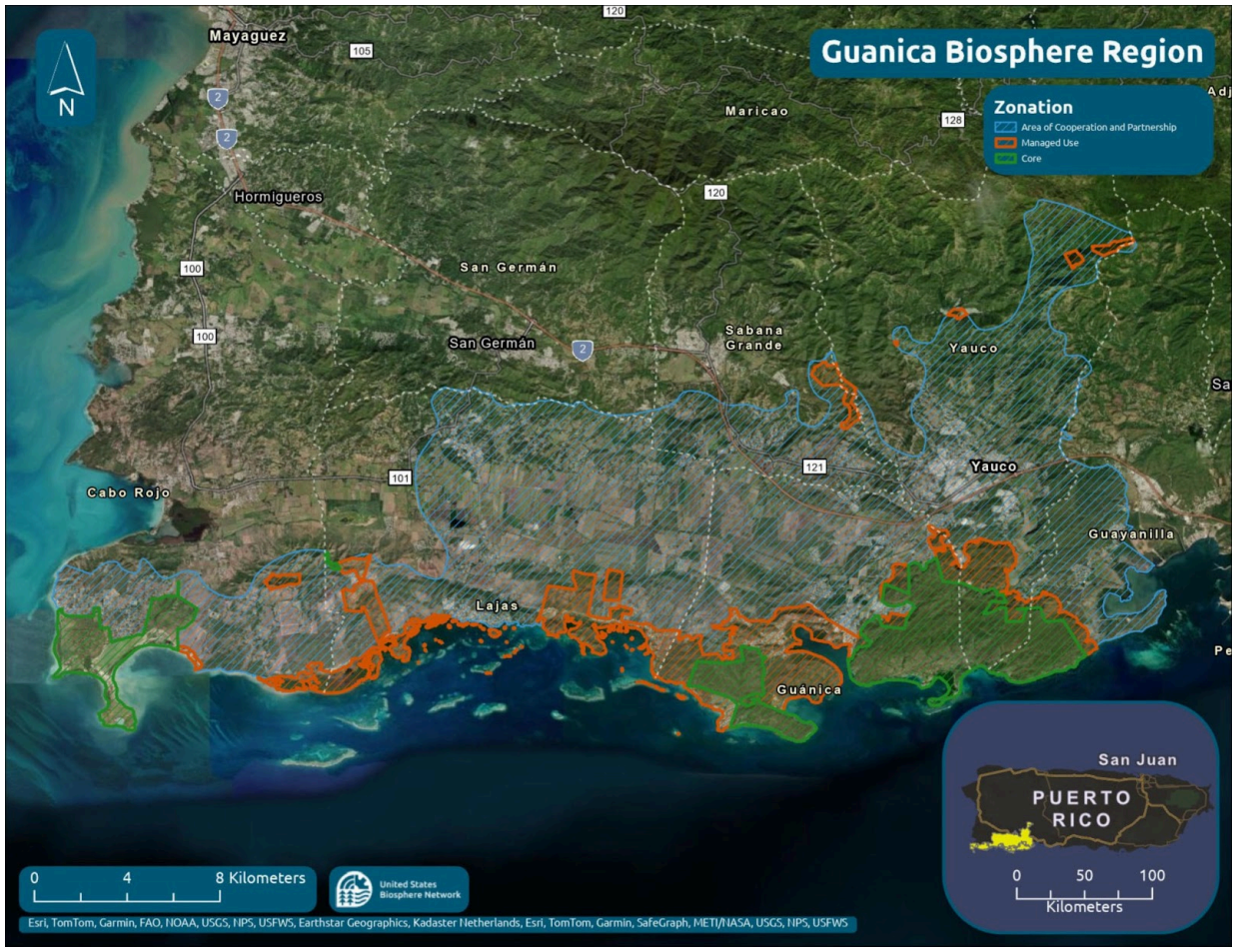
Figure 14a & 14b: Denali and Everglades & Dry Tortugas Biosphere Regions Zonation



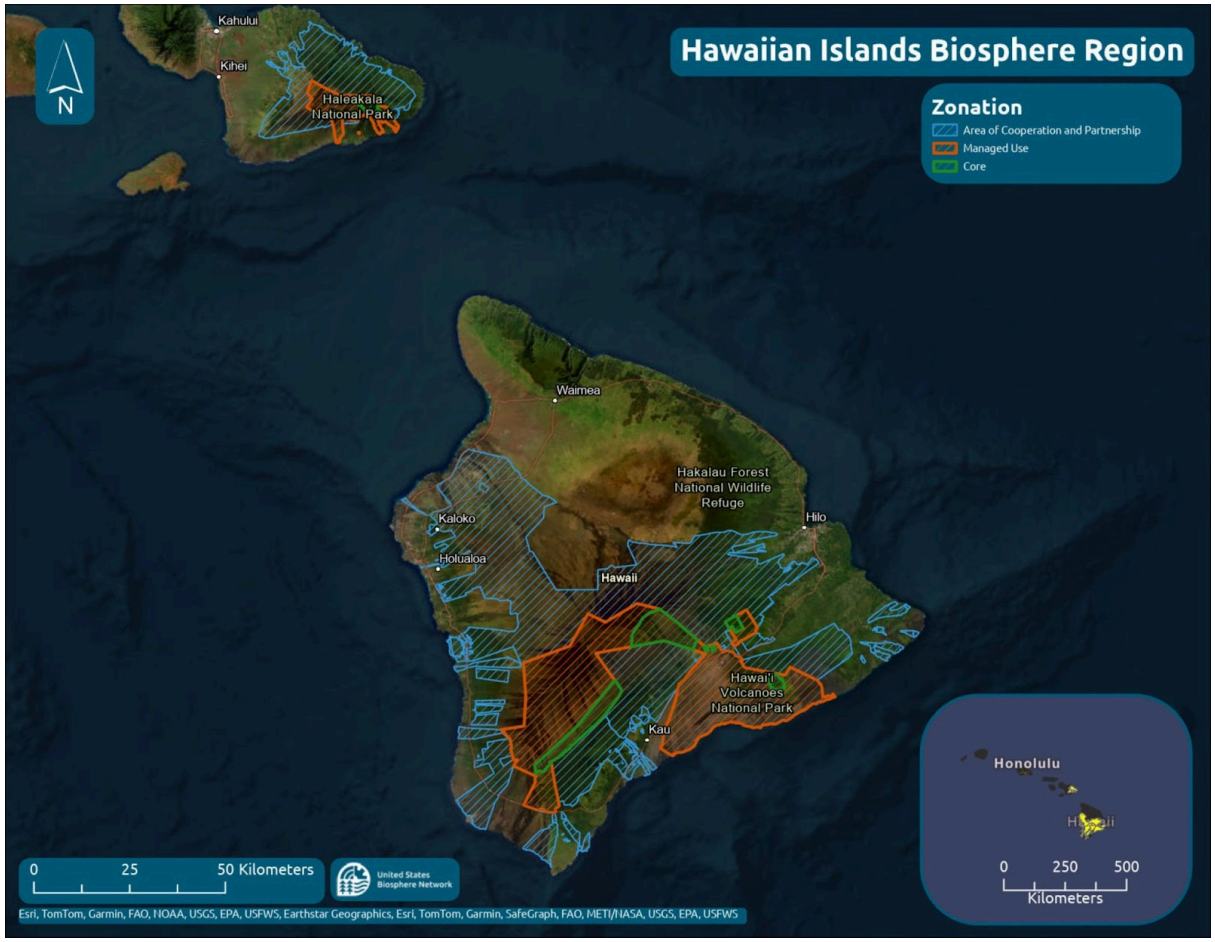

Denali Biosphere Region
Zonation
Area of Cooperation and Partnership
Managed Use
Core
N
UNITED STATES
Alaska
Fairbanks
Anchorage
Cook Inlet
Iliamna Lake
0 115 230 Kilometers
United States Biosphere Network
Esri, TomTom, FAO, NOAA, USGS, Earthstar Geographics, State of Alaska, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS
Ocean
0 1,000 2,000
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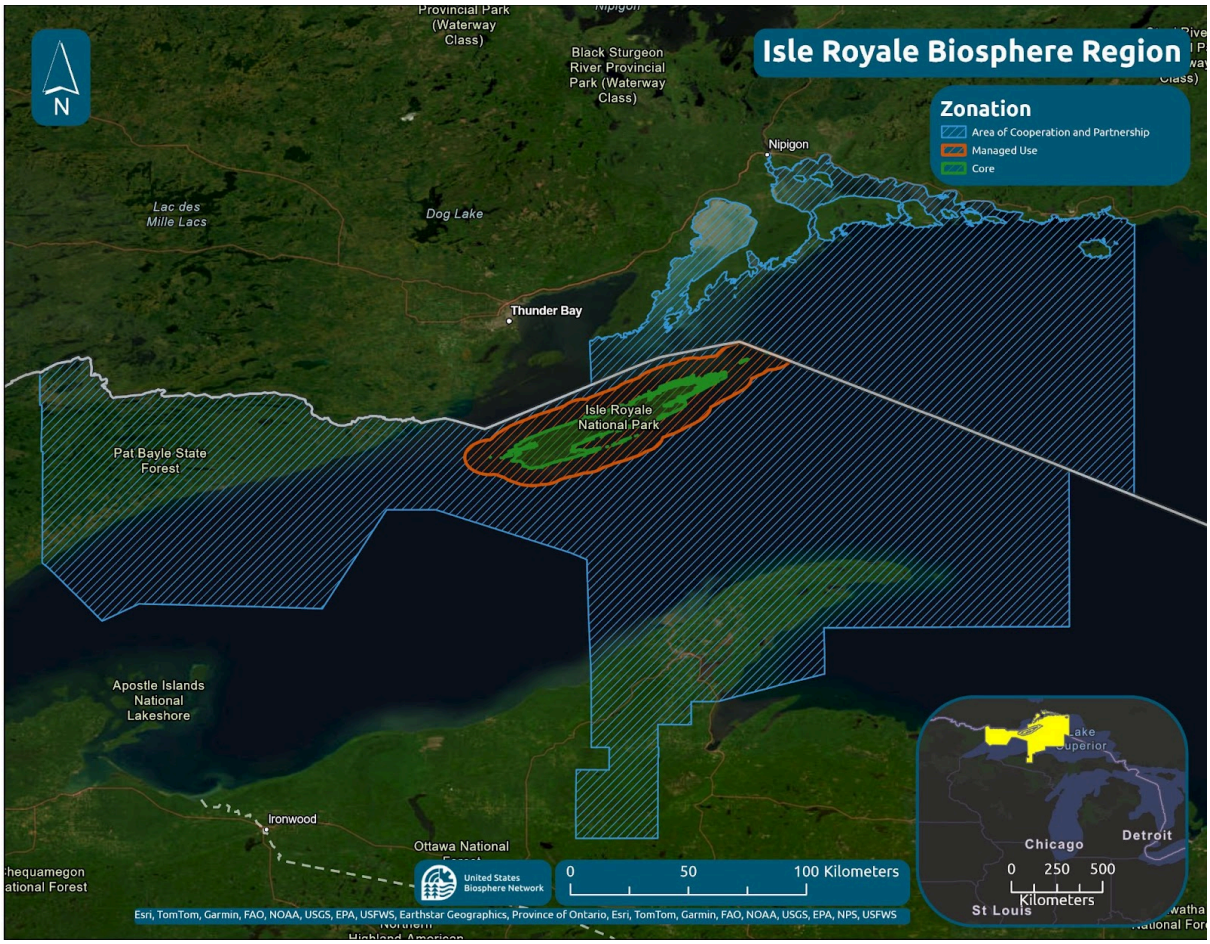
Maps



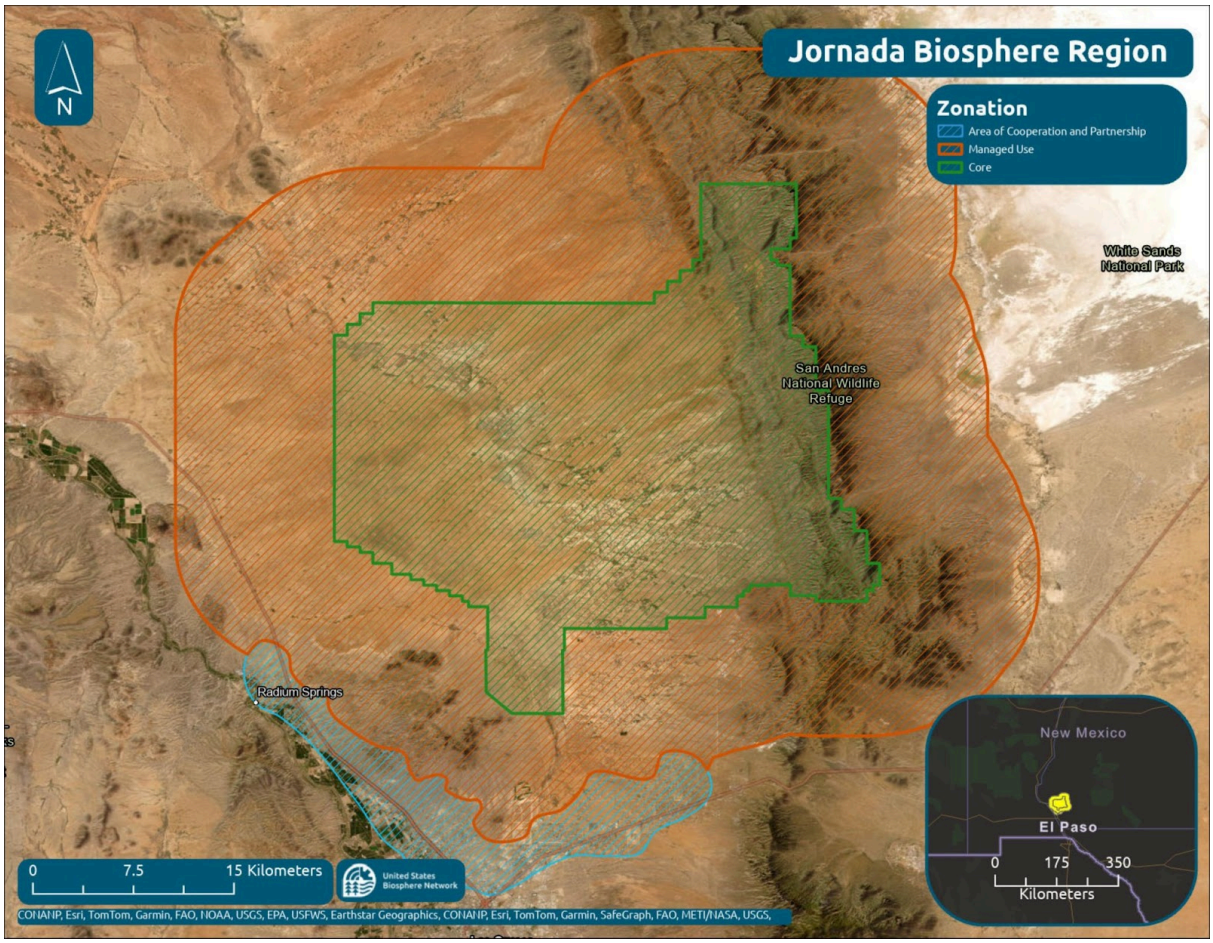


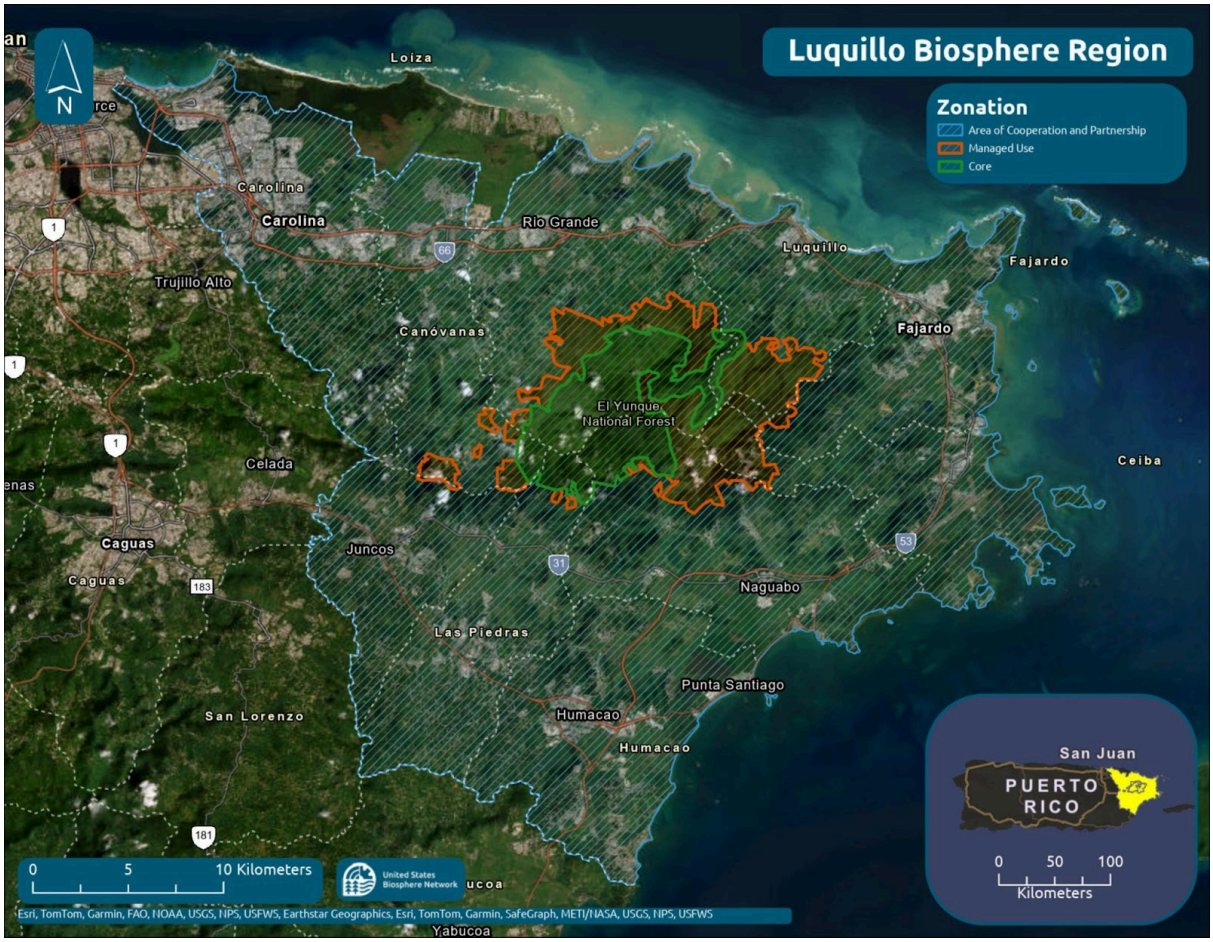
Figures 15a & 15b: Golden Gate and Guánica Biosphere Regions Zonation Maps



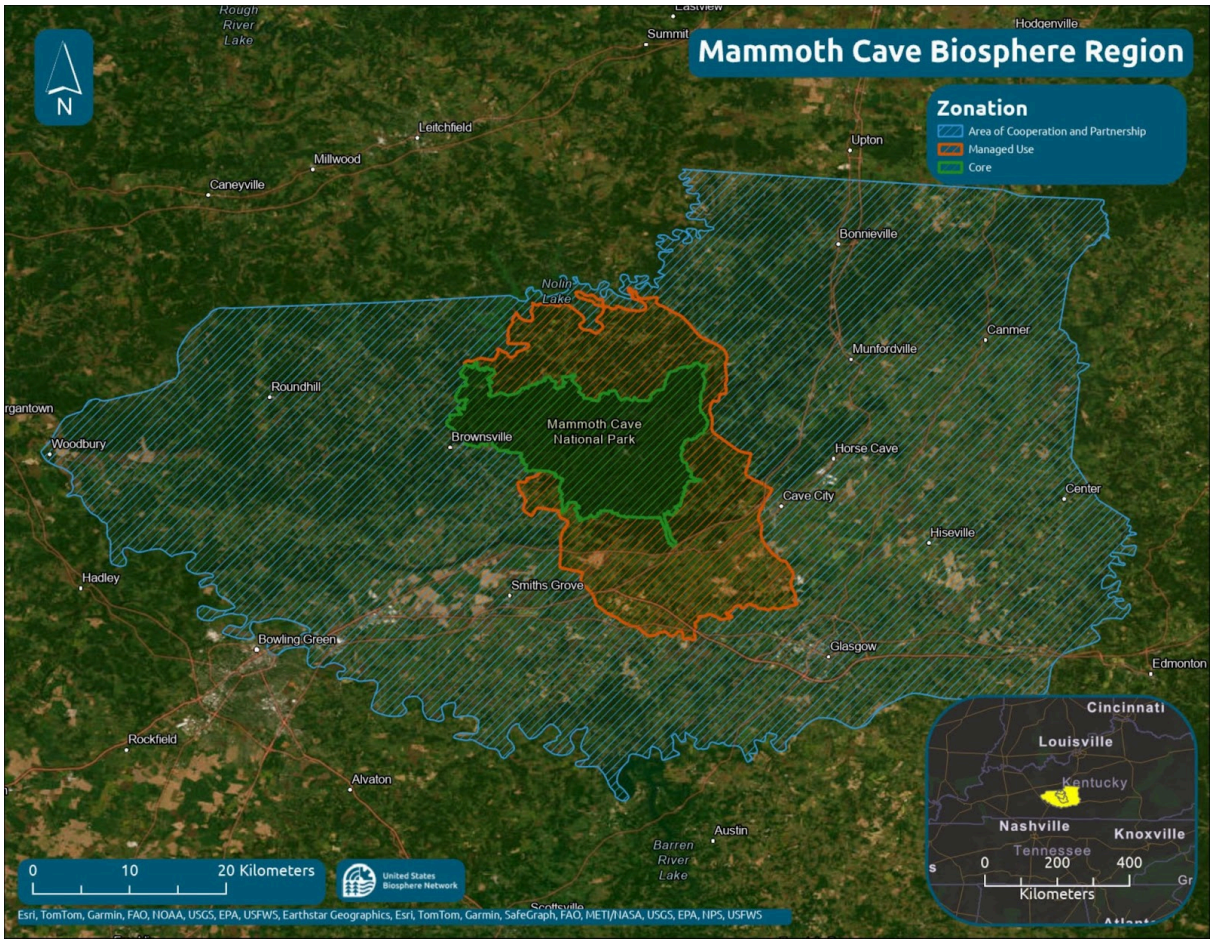


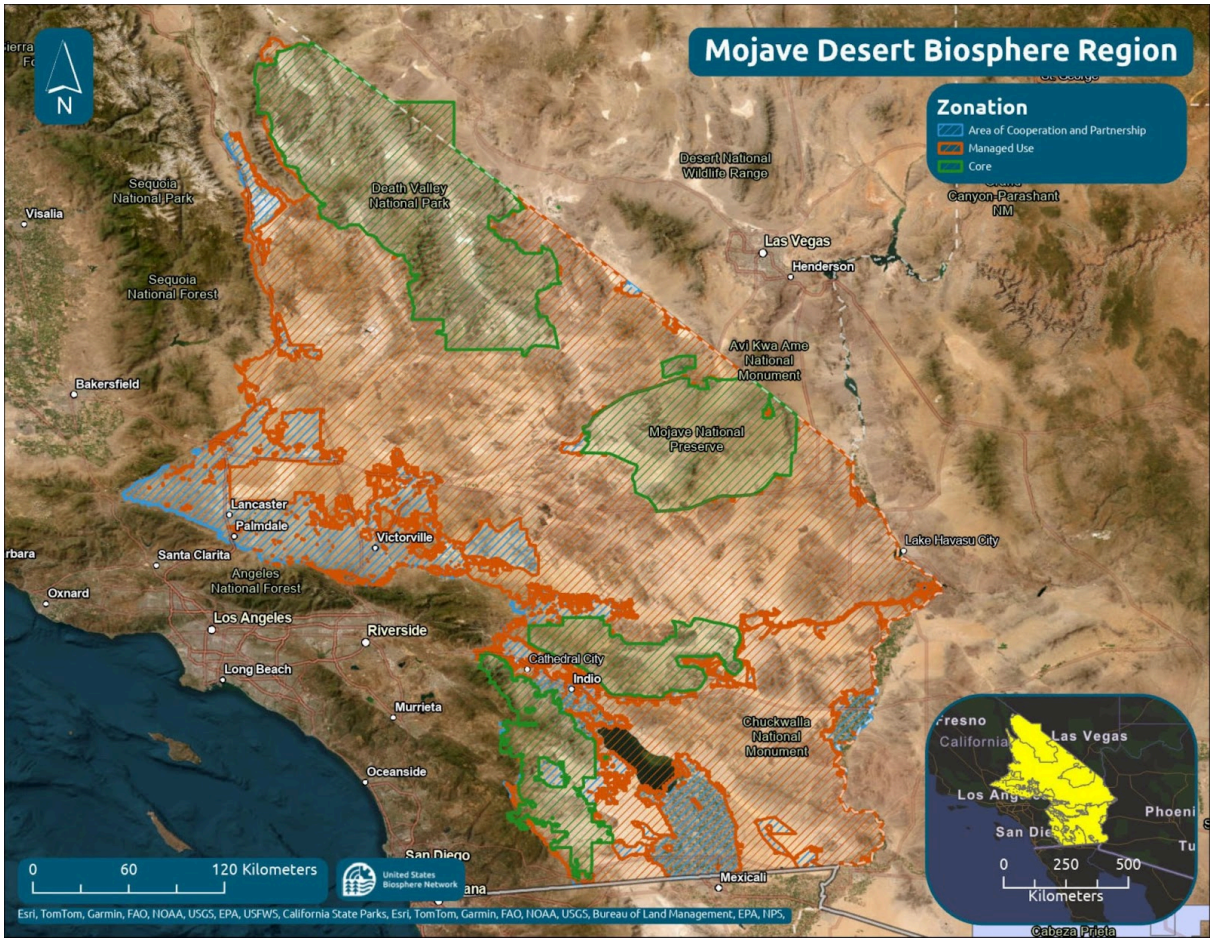
Figures 16a & 16b: Hawaiian Islands and Isle Royale Biosphere Regions Zonation Maps





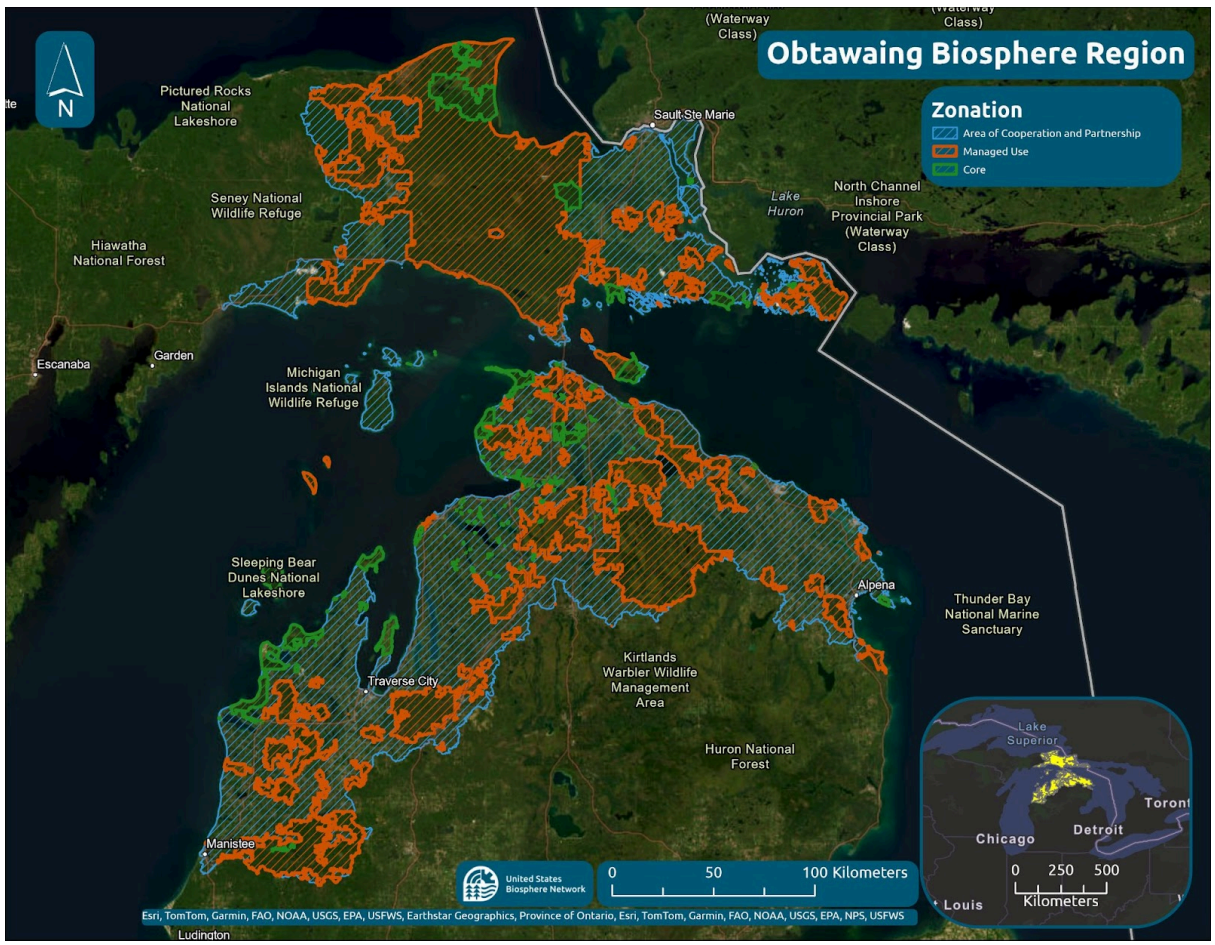
Figures 17a & 17b: Jornada and Luquillo Biosphere Regions Zonation Maps





Figures 18a & 18b: Mammoth Cave and Mojave Desert Biosphere Regions Zonation Maps



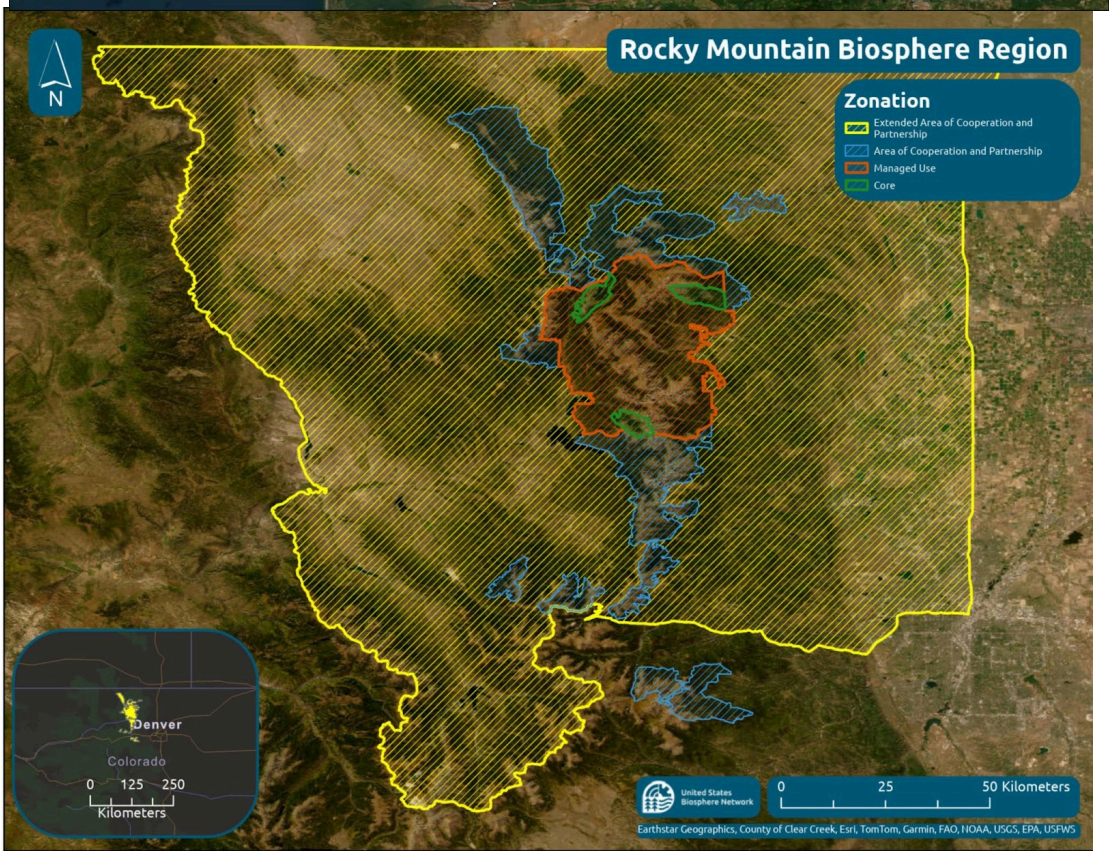


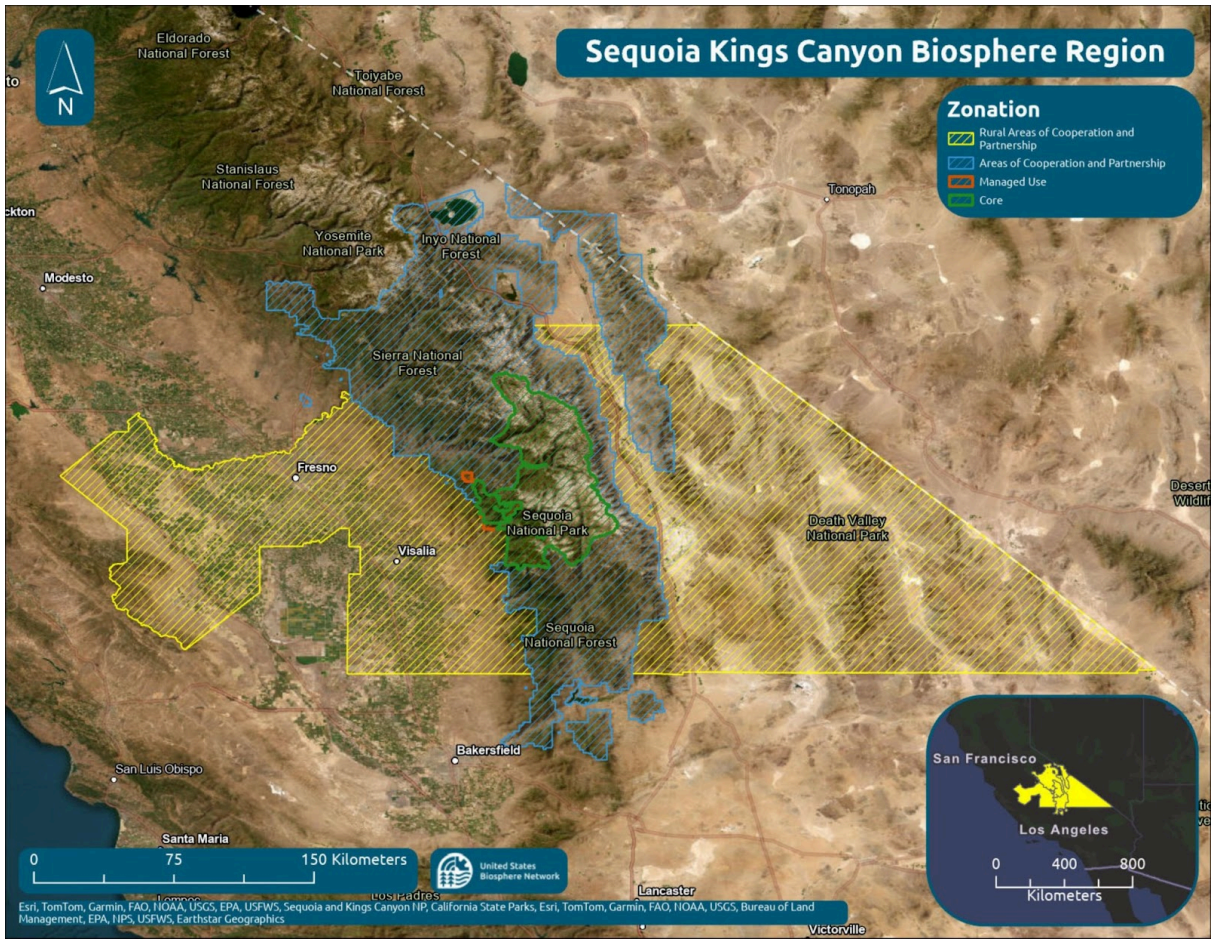
Figures 19a & 19b: New Jersey Pinelands and Obtawaing Biosphere Regions Zonation

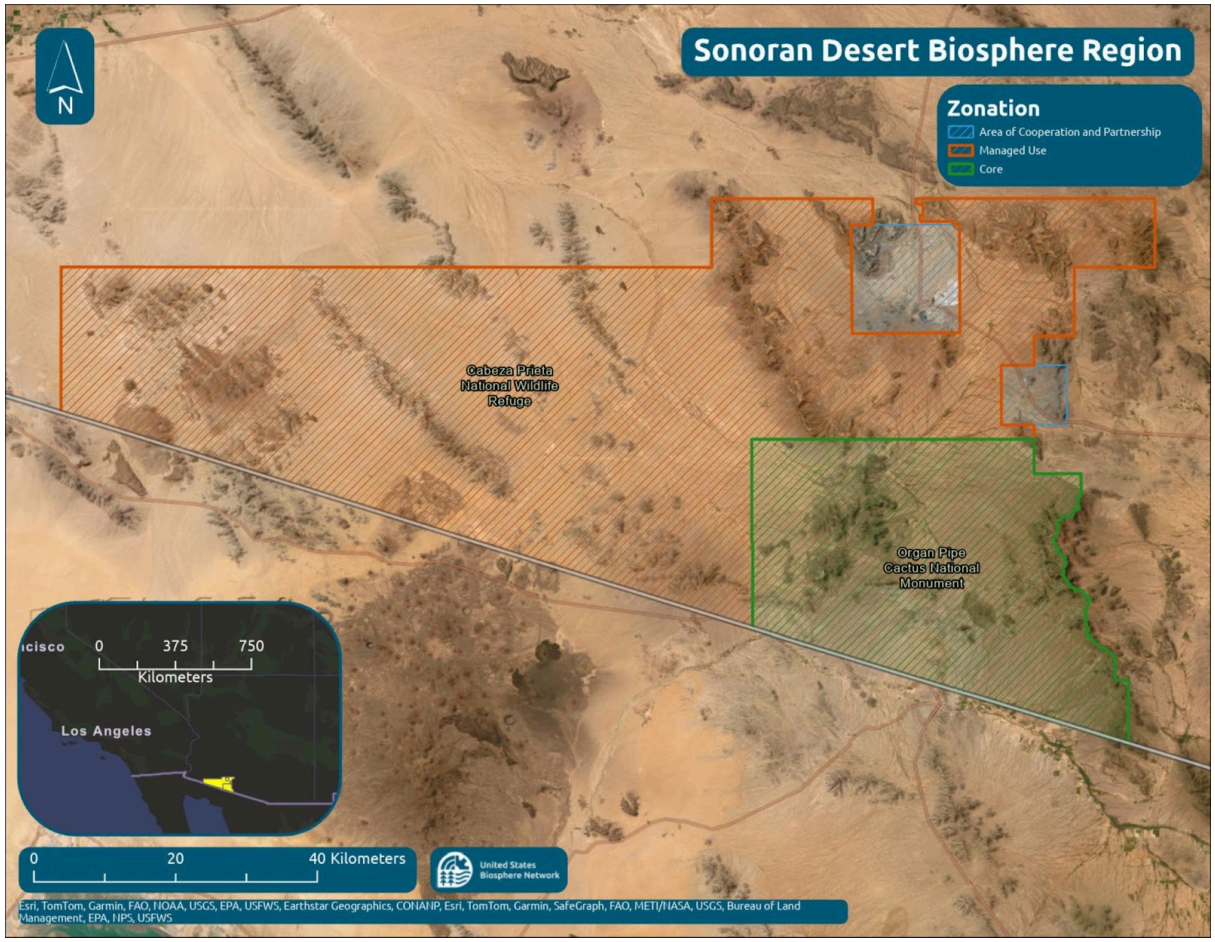
Maps

Figures 20a & 20b: Olympic and Rocky Mountain Biosphere Regions Zonation Maps





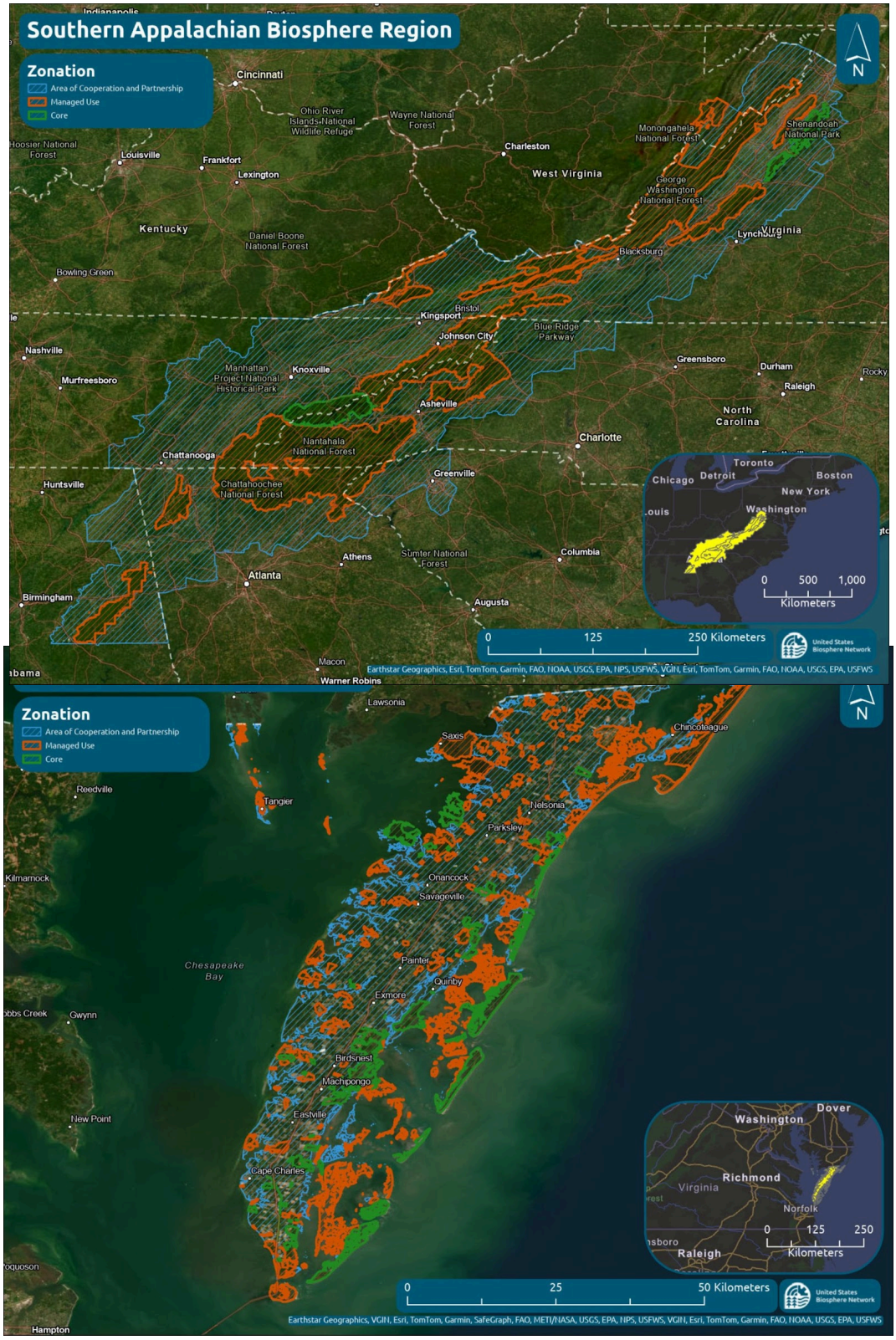




Figures 21a & 21b: Sequoia Kings Canyon and Sonoran Desert Biosphere Regions Zonation

Maps

Figures 22a & 22b: Southern Appalachian and Virginia Coast Biosphere Regions Zonation Maps



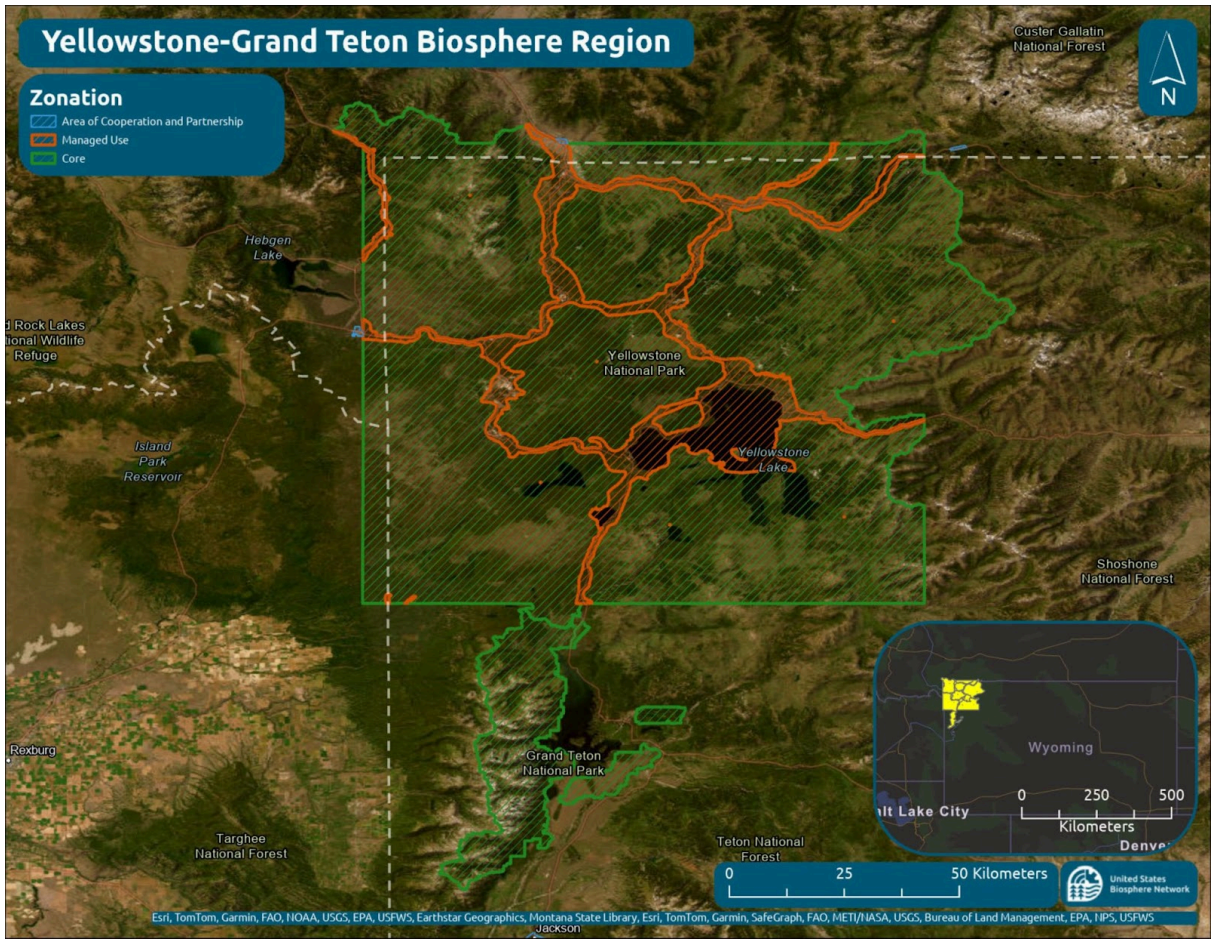


Figure 23: Yellowstone-Grand Teton Biosphere Regions Zonation Maps

Appendix F: ArcPython Map Automation Script

```
import arcpy

# Parameters
biosphere_layer_name = 'Biosphere_Zonation'  # Replace with the name of your layer
name_field = 'BiosphereName'  # Field storing the biosphere region name
template_name = 'Template'
main_frame_name = 'Main Map'
title_textbox_name = 'Title'
output_folder = r'C:\Users\seank\OneDrive\Desktop\USBN_Final_Maps'
title_prefix = ''  # Can add "Biosphere Region:\n" or similar if desired

# Access the project
aprx = arcpy.mp.ArcGISProject("CURRENT")
layout = aprx.listLayouts(template_name)[0]
main_frame = layout.listElements('MapFrame_Element', main_frame_name)[0]
title_textbox = layout.listElements('Text_Element', title_textbox_name)[0]

# Get the zonation layer
zonation_layer = None
for m in aprx.listMaps():
    for lyr in m.listLayers():
        if lyr.name == biosphere_layer_name:
            zonation_layer = lyr
            break
    if zonation_layer:
        break

if not zonation_layer:
    raise Exception(f"Layer '{biosphere_layer_name}' not found.")
```

```
# Loop through each biosphere region feature
with arcpy.da.SearchCursor(zonation_layer, ['SHAPE@', name_field]) as cursor:
    for idx, (geom, name) in enumerate(cursor):

        # Set the map extent with padding
        extent = geom.extent
        padding = (extent.XMax - extent.XMin) / 20
        new_extent = arcpy.Extent(
            extent.XMin - padding,
            extent.YMin - padding,
            extent.XMax + padding,
            extent.YMax + padding,
            extent.spatialReference
        )
        main_frame.camera.setExtent(new_extent)

        # Update title text
        title_textbox.text = f"{title_prefix}{name}"

        # Optional: set a definition query if needed
        zonation_layer.definitionQuery = f"{name_field} = '{name}'"

        # Export to PDF
        filename = f"{idx:02d}_{name.replace(' ', '_').replace('/', '_')}.pdf"
        outpath = output_folder + filename
        layout.exportToPDF(outpath)
        print(f"Exported: {outpath}")
```

Appendix G: StoryMap Data References

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Appendix I: StoryMap Media References

Photo	Photo URL	Photo Credits	Photo Accessibility Text
Header (Estes Park with RMNP in background	—	Sean Skinner	A landscape with forests, roads, fields, and mountains
Apalachicola	Link	Hailey Randell / NOAA (Found in USBN Communications Drive)	Aerial imagery of coastal lands
Big Bend	Link	NPS (Found in USBN Communications Drive)	A canyon with orange rocky cliffs leading to a valley
Big Thicket	Link	NPS Photo / Scott Sharaga	Cypress trees within the swamp
Cascade Head	Link	Cascade Head Biosphere Collaborative	An aerial view of beaches with forest along the water
Champlain-Adirondack	Link	Brendan Wiltse (Found in USBN Communications Drive)	A person at a rocky overlook among mountains in the autumn time
Channel Islands	Link	NPS	Overlooking the coastal lands of the Channel Islands
Congaree	Link	Congaree Biosphere Collaborative	A green swamp with trees and stumps sticking out of the water
Crown of the Continent	Link	NPS / Tim Rains	Rocky and snowy mountains above green fields with forests
Denali	Link	NPS / Emily Mesner	Snow covered mountains in the background
Everglades	Link	NPS	An aerial view of a boater going through water and mangrove islands surrounding him
Glacier Bay	Link	NPS	Icy glaciers and rocky mountains protruding from the earth

Golden Gate	Link	Matt McIntosh / GFNMS	Deer looking into the camera on the California coastline
Guanica	Link	Carlos Rodriguez-Sallaberry via AllTrails	A dry prairie with cactus and brush
Hawaiian Islands	Link	Barbara Billan / NOAA (Found in USBN Communications Drive)	Magma pours off rocks and into the ocean
Isle Royale	Link	NPS / Jim Peaco	An aerial view of forested islands and beaches
Jornada	Link	NEON Science	A partly cloudy sky with desert plants and mountains
Luquillo	Link	USBN Comms Team (Found in USBN Communications Drive)	A sunset over a mountainous area with fog
Mammoth Cave	Link	NPS Photo/ Ashley Decker	Water pours into the cave from the ceiling near Frozen Niagara.
Mojave Colorado Deserts	Link	NPS / Carmen Aurrecoechea	A field of palm trees with dry grass below and mountains in the background
New Jersey Pinelands	Link	Paul Leakan	A sunset over a lake with birds flying around
Obtawaing	Link	University of Michigan Biological Station (Found in USBN Communications Drive)	Dry sky at the UMBS
Olympic	Link	OCNMS / Matt McIntosh (Found in USBN Communications Drive)	An opening in a forest with autumnal trees surrounding a grassy field
Rocky Mountain	Link	NPS (Found in USBN Communications Drive)	Pond with water reflecting the landscape of forests and snow covered mountains
Sequoia Kings Canyon	Link	NPS / Kiel Maddox	A rocky shore with pine trees and mountains in the background

Sonoran Desert	—	Sarah Davis	Tall cactus in a sandy desert with a mountain behind it that is lit in sunlight
Southern Appalachian	Link	Southern Appalachian Man in the Biosphere	Rolling forested mountains with fog settled in the foothills
Virginia Coast	Link	TNC VCR	An aerial view of marsh land with meandering rivers and forests
Yellowstone Grand Teton	Link	NPS (Found in USBN Communications Drive)	A steaming hot spring with orange and red substrate and a forested mountain above
Cascade Head Headlands	Link	The Nature Conservancy of Oregon	Looking downhill, people hiking down a grassy slope that meets the ocean
The Secret Life of Salmon	Link	The Cascade Head Biosphere Collaborative	A video series made by the CHBC about the life history of salmon
School of Blackrock Fish	Link	Oregon Kelp Alliance	A school of fish swimming underwater
European Green Crabs in fuaki traps	Link	4Cast Project	Crabs in a metal trap on the beach
Biosphere Explorience Promotional Poster	Link	Sarah Davis, Cascade Head Biosphere Collaborative and Explore Lincoln City	Photos of people outside, rivers, and forests with a logo of a trout in front
2023 Art on the Beach	Link	Casacde Head Biosphere Collaborative	
Aerial of the Cascade Head Biosphere	Link	Duncan Berry	Aerial view of a coast with forests and beaches
Golden Gate Bridge	Link	Golden Gate Biosphere Network	A red bridge over the ocean
GGBN Climate Vulnerabilty Assessment (Video)	Link	Golden Gate Biosphere Network	
Ocean Beach	Link	San Francisco Public Utility Commission.	Construction machines and people on a sandy beach

Climate Change Adaptation Project			
Bull Kelp	Link	iNaturalist User	Green plant half submerged in water along rocks
Redwood Renewal Project Map	Link	NPS	A poster with a green background and symbols of water, people, cars, and fish
Shore of GGBN	—	Sam Kocurek	Rocky green hills meeting beaches and ocean water
West Pine Plains	—	John Bunnell	A path of white sand cutting through a green forest
Cedar Forest	—	Paul Leakan	A wooden bridge in the middle of forested swamp land
Pinelands Wildlife Collage	—	Paul Leakan	Otter laying on a boardwalk, two osprey in an elevated wooden nest, a purple flower with a bug, and a turtle with its limbs inside its shell
Kirkwood-Cohansey Aquifer	—	Paul Leakan	Close shot of water falling
Pitch Pine Trail	—	Paul Leakan	A winding white sand path through a forest and a white sign with red writing
Prescribed Burn Sign	Link	Florida Forest Service - Waccasassa Forestry Center	A orange diamond-shaped sign with black text
Wharton State Forest Prescribed Burn Collage	—	Paul Leakan	Collage of people walking in yellow coats, red trucks, and fire burning brush
Whitesbog Village Wet-Harvesting Collage	—	Paul Leakan	Collage of yellow trucks with red bogs full of cranberries
Pine Barrens Tree Frog	—	John Bunnell	A tiny green frog hugging a stick
Sunset over Atsion Lake in Wharton State Forest	—	Paul Leakan	A sunset with shadowed black trees in the foreground

Organ Pipe Cactus National Monument Sign	—	Sarah Davis	A sign with black writing, taupe rock, and a logo of an arrowhead with white writing
Sonoran Desert Biosphere	—	Sarah Davis	Hills of green shrubs and cactus with reddish brown hills and soil
Sonoran Wildlfie Collage	Link	iNaturalist Users	Collage of photos with green cactus plant and pink flower, a brown boar with its nose to the ground, a small brown mouse, and green brush plants with yellow flowers
Artists Alley in Ajo, Arizona.	—	Sarah Davis	Mural of walls with colorful art of people and nature
Historic Adobe Reconstruction	Link	Cornerstones Community Partnerships	A rocky structure being built in a sandy desert
Ramada Construction	Link	NPS / E. Schnaubelt	Sonoran Desert Network staff work hard building the second ramada. The rightmost photo displays the mesquite frame and ocotillo roof of the first ramada. The new ramada will look similar, but larger, when completed; the ocotillo in a pile in the leftmost photo will become the roof.
Tradtional Cactus Fruit Harvesting	Link	Trust for Public Land.	Two native american women use tradatiional harvesting methods to collect the fruit of a cactus
Quitobaquito Springs restoration	Link	International Sonoran Desert Alliance	Collage with people, a brown pond, and green plants
Pinacate Peaks	Link	Alejandro Olivera from the Center of Biological Diversity.	A brown rocky circle in the earth
Sonoran Desert Sunset	Link	Encyclopaedia Britannica	A pink, orange, and yellow sunset with the black shadows of cactus in the foreground
Mammoth Cave Entrance	Link	NPS Photo/ Deb Spillman	Opening to a cave surrounded by green vegetation
Collage of Mammoth Cave Wildlife	Link	Rongkai Zhong and iNaturalist Users	Collage of various species that would be found within the Mammoth Cave Biosphere Region
Frozen Niagara	—	Rongkai Zhong	Dripstone formations within Mammoth Cave

Cleaveland Avenue	Link	NPS Photo/ Thomas DiGiovannangelo	Sparkling gypsum crystals within Mammoth Cave
Gothic Avenue	Link	NPS Photo/ Jackie Wheet	The dark interiors and human-made structures within Mammoth Cave
Hidden Wonder: Mapping Mammoth Cave.	Link	NPS and Peter Argentine	
Karst Landscape	Link	NPS	Aerial view of the karst landscapes sinkholes
Mammoth Cave Exit	Link	NPS Photo/ Deb Spillman	A view out of the dark cave to the surface of Mammoth Cave
CABN with Canoe	Link	Brendan Wiltse (Found in USBN Communications Drive)	People in life jackets in yellow kayaks on water surrounded by forested mountains and a cloudy sky
CABN Collage	—	Sam Kocurek, Alaina Smith, Anna Marchessault, Lewis Creek Association, Tom DeBell, Pamela Rossi Brangan, Jackson Derrick, Isle La Motte Preservation Trust	A collage of green plants, pink and purple flowers, a brown duck, children playing, water and green mountains, people fishing in a lake, golden glass bottles, and a yellow water bottle with a sticker
Wild Center Collage	—	The Wild Center, CABN	A collage with people playing on platform, a valley with red, orange, and yellow trees, and an elevated path among green tree tops
Dairy Farming Collage	—	New York Department of Agriculture and Markets, Shelburne Farms, Cornell Cooperative Extension Essex County	A collage with black and white cows, a hand holding white circular seeds, a building with a green field in front, a glass of white milk, and an aerial view of land with pasteur, buildings, and roads
CABN Sunset	Link	Brendan Wiltse (Found in USBN Communications Drive)	A cloudy sunset with black shadowed people in the foreground

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