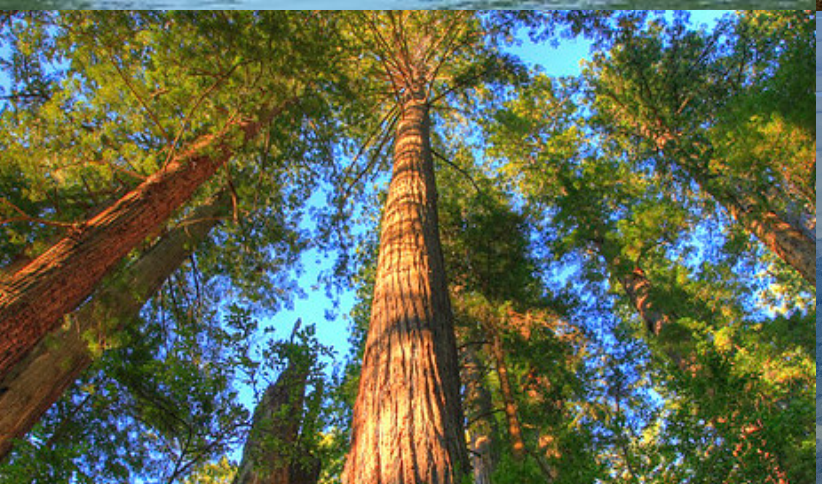
The Wilderness Society

SEAS SCHOOL FOR ENVIRONMENT AND SUSTAINABILITY UNIVERSITY OF MICHIGAN

PROTECTING HIGH CARBON AREAS IN THE UNITED STATES:

OPPORTUNITIES, POLICY MECHANISMS, AND COMMUNICATIONS STRATEGIES



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This report is one of the final products that culminated from a Master's Capstone Project at the University of Michigan School for Environment and Sustainability. The project took place from January 2022 - April 2023. The team partnered with The Wilderness Society to inform TWS's analysis and advocacy to enhance conservation of high carbon areas.

A visual representation of the team's findings as well as specific case studies can be found in **this StoryMap**.

Cascades, WA - Sophie Daudon

ACKNOWLEDGEMENTS

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- All our interviewees who gave time and thoughts in interviews over the past year. We are grateful for their countless insights and professional and personal reflections on conservation efforts.

Cover page photos: Mangroves, FL - Chris Schieman; Northern Forests, NH - Francesca Governali; Headwaters Forest Reserve, CA - BLM; Noatak River, AK - Lily Xu

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INTRODUCTION

Right Upper: U.S. Total IRC; **Right Lower:** IRC designation process using category boundaries based on IRC density.

IRRECOVERABLE CARBON OVERVIEW

A focus on carbon storage as one benefit of land conservation has grown in recent years due to a greater appreciation of the role of nature-based climate solutions to mitigate climate change. Conservation NGOs are emphasizing carbon conservation as a goal, governments are creating carbon-focused land management policies, and businesses focused on "carbon credits" are expanding.[1,2,3] But, which carbon is the most valuable and vulnerable? With so many threatened areas, which should be chosen as the most important to protect?

First introduced in 2020 and mapped in 2021, irrecoverable carbon provides a framework for prioritizing conservation efforts.[4] **Irrecoverable carbon (IRC)** describes dense stores of above- and below-ground carbon, sequestered in biomass and soil over decades to millennia, that are vulnerable to release into the atmosphere by human activities. If released, this carbon will not be restored or naturally re-sequestered by 2050, the point at which the world must reach net-zero emissions to avoid the worst consequences of climate change.[5] It is commonly measured in megagrammes (Mg), with Mg per hectare or acre used for density. In this report, you will also find IRC measured in megatonnes (Mt), where 1 million Mt is equal to 1 Mg.

Biomass IRC: Aboveground biomass; including plant stems, trunks and leaves) plus belowground biomass (including roots).

Soil IRC: Soil organic carbon (SOC) to a depth of 30 cm for upland mineral soils and 1 m for waterlogged peat and coastal systems.

In this report, we provide an overview of IRC areas within the United States and a characterization of the primary threats to and possible pathways to protection for high carbon areas. We present case studies from across the United States to inform landscape prioritization and management by NGOs, federal and state agencies, and policymakers.

METHODS - U.S. IRC CHARACTERIZATION AND HIGH CARBON AREAS

For our analysis, we categorized IRC across the United State into 10 **High Carbon Areas (HCAs)**. These areas were identified and delineated on the basis of 1) the densest concentrations of IRC, 2) common ecosystem types, and 3) shared cultural characteristics (less of a focus). The primary objective in delineating HCAs was to identify these spatially distinct areas of high IRC across the U.S. in a way that enabled further qualitative analysis by HCA. See the appendix for additional information about the geospatial methods that were applied (Appendix A).

We then used the HCA as our unit of analysis. Within each area, we performed GIS analysis of ecosystem type, landowner and manager, and GAP status (a measure of degree of land protection). Additionally, we conducted interviews with regional experts in each HCA to gain a more nuanced understanding of the challenges and opportunities involved in carbon protection in each area.

HCAS "AT A GLANCE"

To understand the factors enabling and limiting IRC protection, we compared HCAs in terms of cultural context, ecosystem type, ownership and manager breakdown, major threats, and possible paths to protection. Below is a high-level overview of the similarities and differences we observed across HCAs. Note that some details critical to IRC protection, such as the cultural context for each region, are not explored below but instead further unpacked in each HCA case study.

ECOLOGICAL CHARACTERISTICS

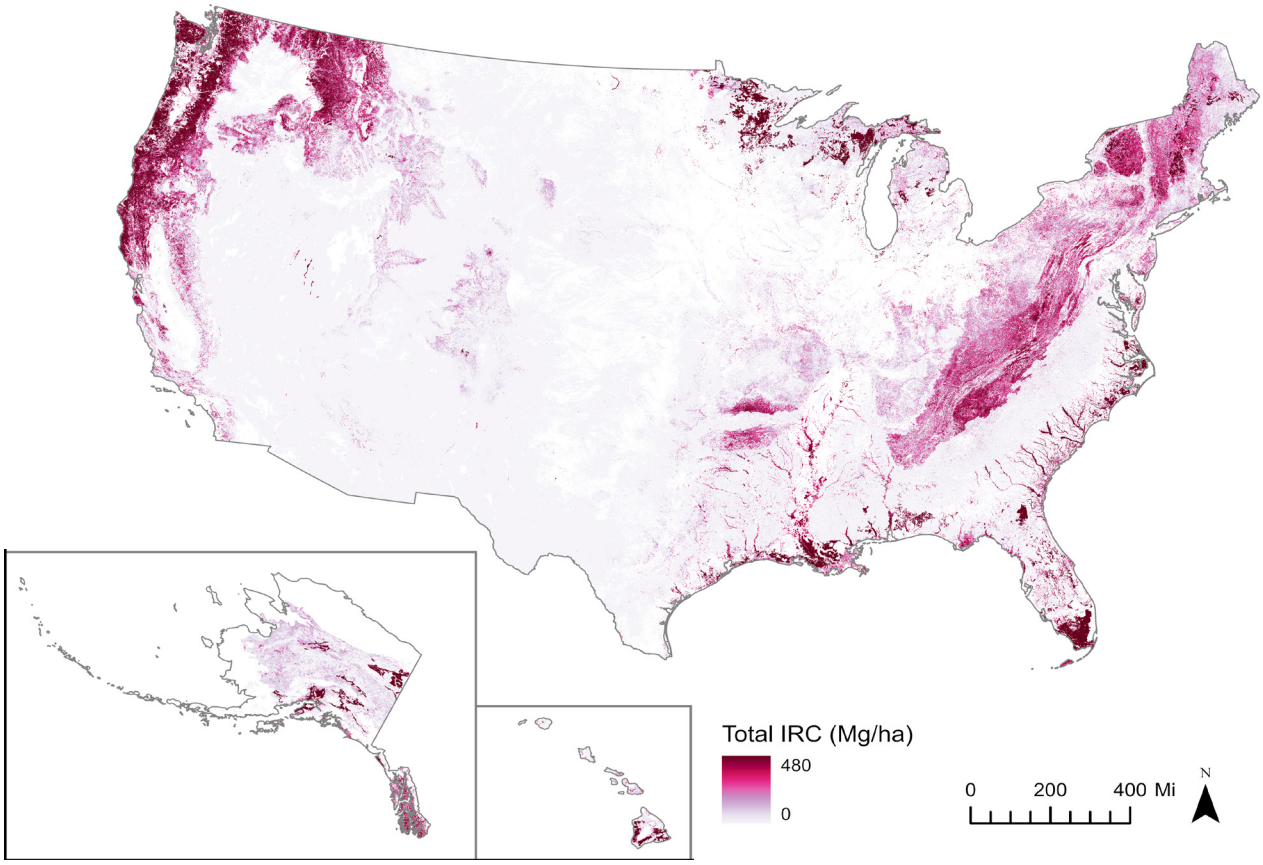
IRC Quantity and Densities across HCAs

The amount and density of IRC in each HCA gives insight into where the greatest stores are found and can help inform prioritization and protection strategy. Alaska has the most IRC, but the lowest density due to its large land size. The Pacific Northwest and Appalachia have the second largest IRC concentrations, while the Sierra has the smallest amount of IRC. However, HCAs with IRC predominantly stored in soils (e.g., wetlands and peatlands) rather than biomass (e.g., forests) have significantly higher densities of IRC per acre (Figure 1).

For example, South Florida and the Gulf Coast have vastly higher IRC densities than other HCAs due to the carbon-rich salt marshes and mangroves in those regions.

PRIMARY RESEARCH QUESTIONS

- Where are high carbon areas (HCAs) located in the U.S.?
- What characterizes the IRC in each HCA, in terms of the ecosystems present in the HCA and land ownership patterns?
- To what extent is IRC protected in each HCA? What are the primary threats?
- What policy and communications strategies can be used to address threats and enhance IRC protection?
- Which HCAs should take priority for IRC protection efforts?
- What additional information is needed to inform IRC protection?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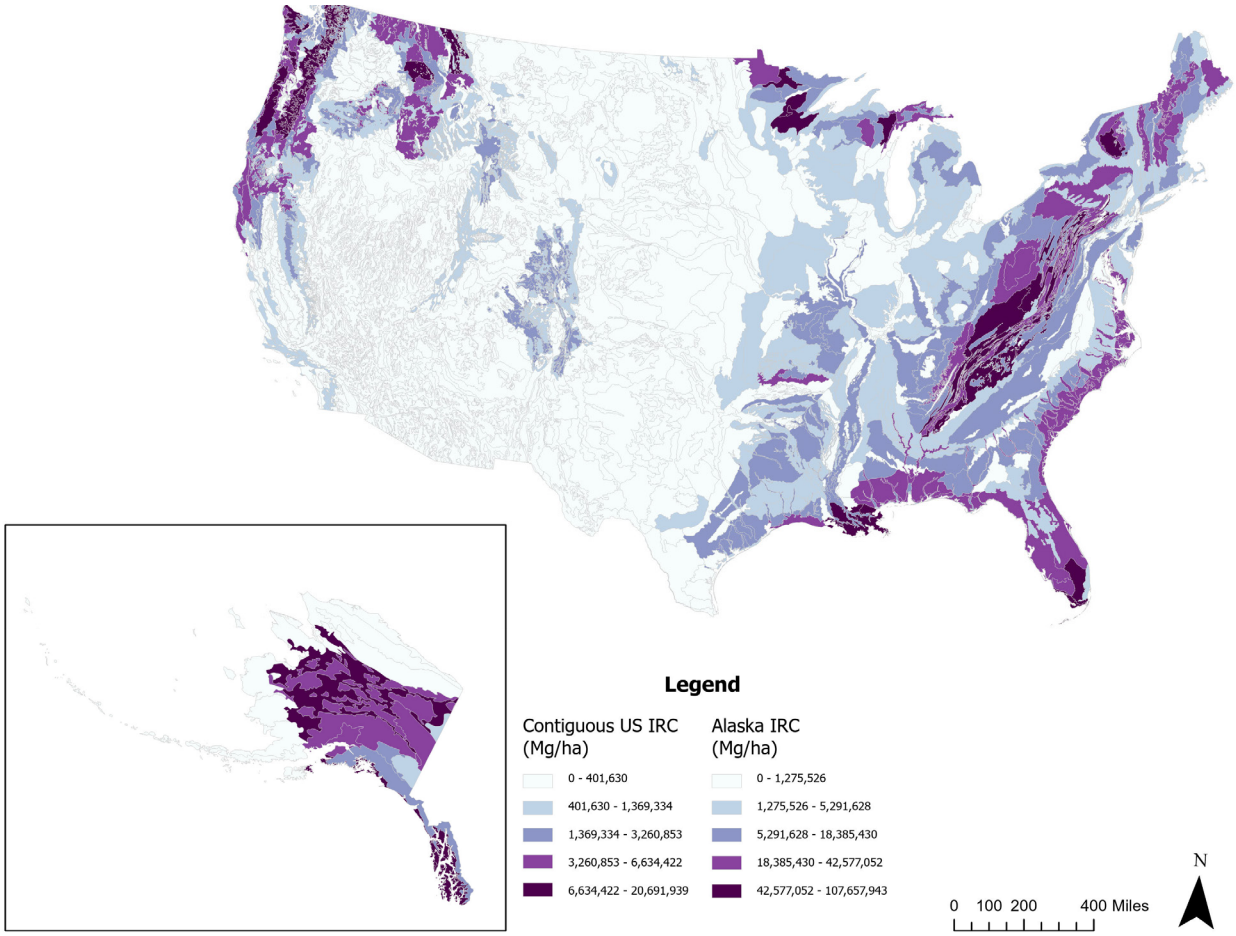
Legend
Contiguous US IRC (Mg/ha)
0 - 401,630
401,630 - 1,369,334
1,369,334 - 3,260,853
3,260,853 - 6,634,422
6,634,422 - 20,691,939
Alaska IRC (Mg/ha)
0 - 1,275,526
1,275,526 - 5,291,628
5,291,628 - 18,385,430
18,385,430 - 42,577,052
42,577,052 - 107,657,943
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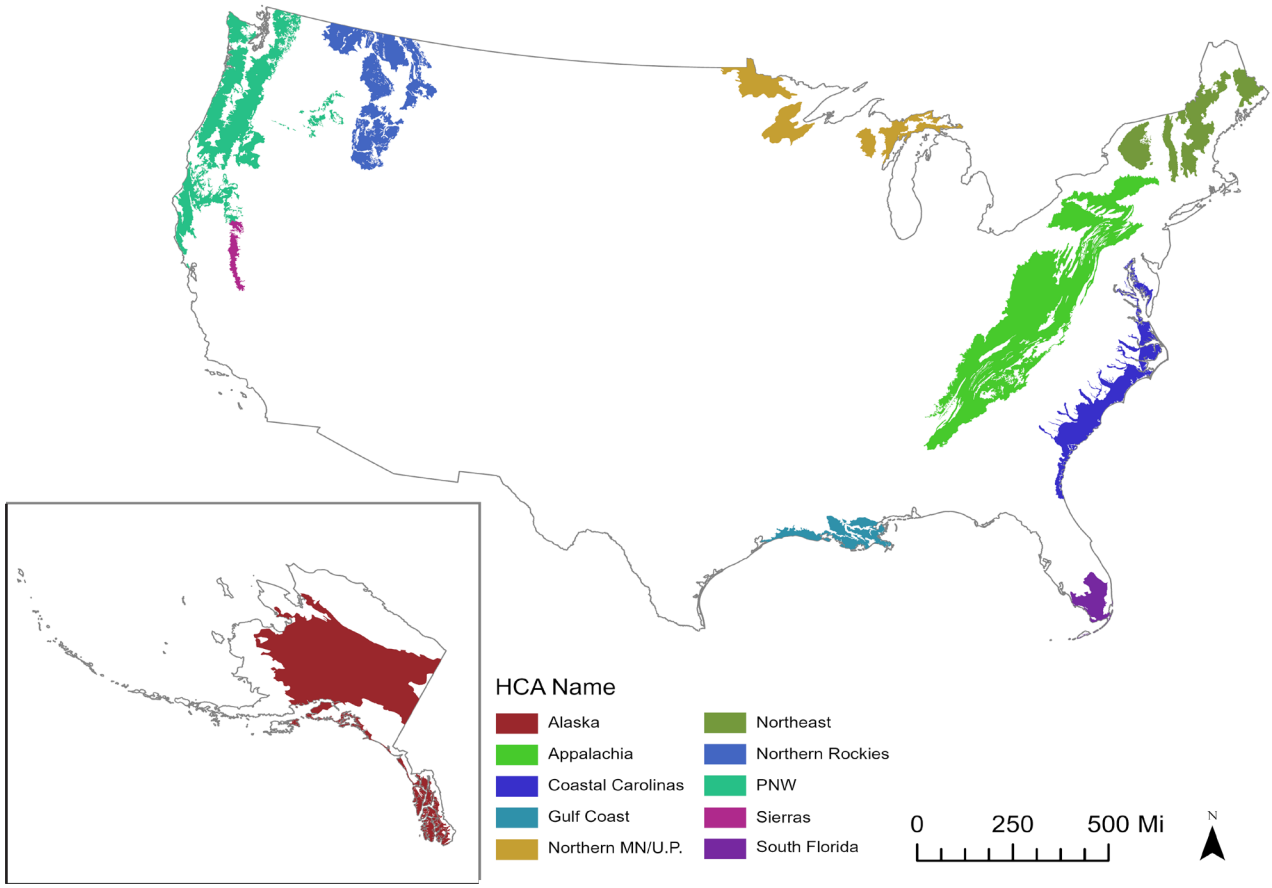


High Carbon Area designations based on group identification process.

Ecosystem Types across HCAs

In the Western HCAs – the Pacific Northwest (PNW), Northern Rockies, and Sierras – IRC is almost entirely found in coniferous forests, ranging from old-growth coastal forests, to redwoods, to mixed moist conifer. Similarly, nearly 100% of the IRC stored in the Eastern Mountains of the U.S. (Appalachia and the Northeast) is in biomass, primarily deciduous forests. By contrast, in the Northern Minnesota and Upper Peninsula HCA (Northern MN / U.P.), Coastal HCAs and in South Florida, IRC is primarily stored in peatlands and salt marshes. Alaska's IRC is split between its forests and peatlands.

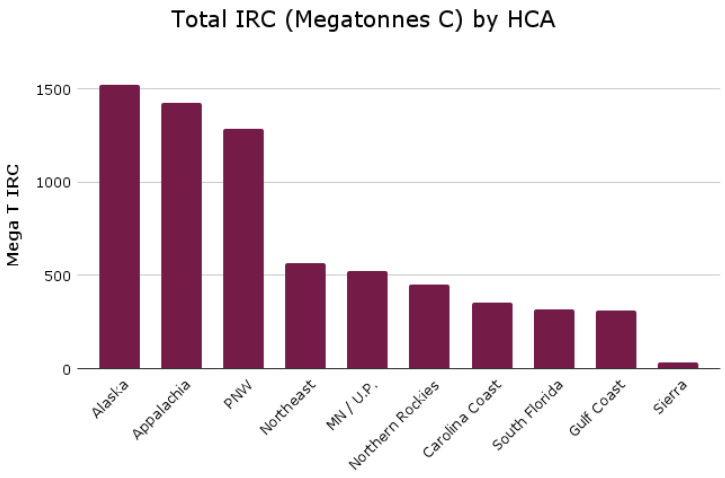


Figure 1: Total IRC (Mt) by HCA.

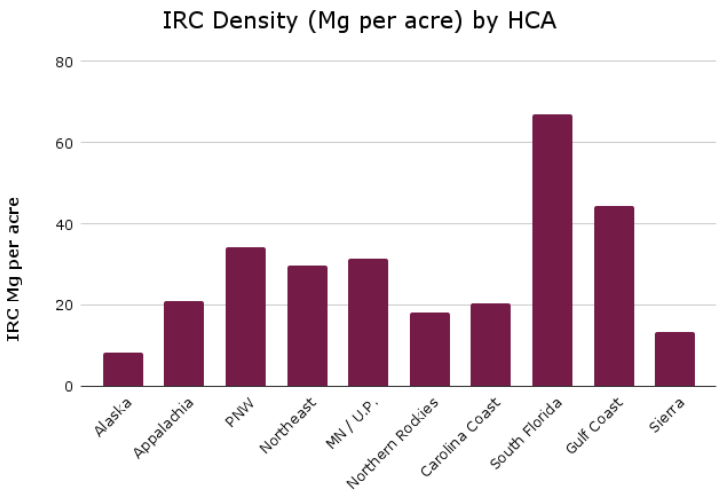


Figure 2: IRC density in megagrammes / acre by HCA. Note unit change used to scale IRC quantity to make per acre amounts more understandable.

IRC OWNERSHIP AND MANAGEMENT

Ownership Across HCAs

Across the U.S., the majority of IRC is either federally or privately owned, but ownership characteristics vary significantly by region. In Western HCAs and Alaska, more than 45% of IRC is owned by the federal government. In Eastern HCAs, 69% or more of IRC is private. Ownership breakdown varies more in the Northern MN / U.P., South Florida, and Alaska HCAs, as shown in Table 1.

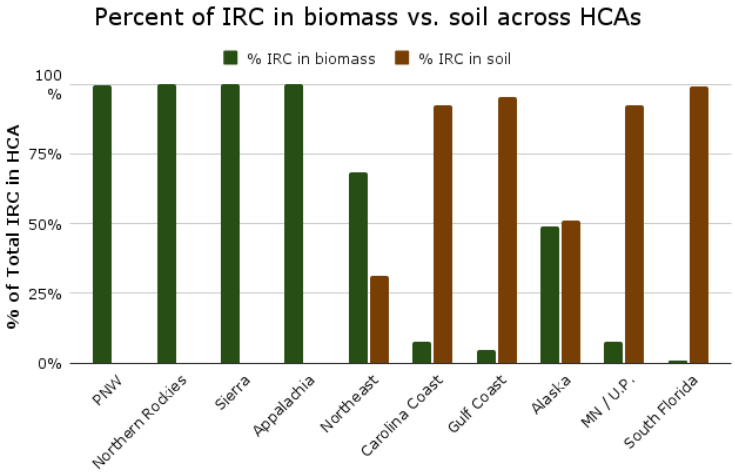


Figure 3: Breakdown of IRC into IRC held in biomass and IRC held in soil, by HCA.

Management Across HCAs

The Forest Service (USFS) is the primary federal manager of lands containing IRC, followed by the Bureau of Land Management and the Fish and Wildlife Service. State land managers include Departments of Natural Resources, Conservation, and Parks and Recreation (Figure 4). Private land managers are harder to identify and comprise a conglomeration of small family owners, timber companies, and corporations.

Tribal Government Ownership and Management

While tribal governments own and/or manage a relatively small proportion of IRC land, their historical treaty rights (which may or may not be legally recognized) and/or ancestral lands include all U.S. IRC. The degree of tribal sovereignty and land management varies throughout the U.S., with greater influence and management rights afforded to Western U.S. and Alaska tribes.

PROTECTION AND VULNERABILITY

GAP Status

GAP Status codes are used to describe the "measure of management intent to preserve biodiversity" of land areas. GAP Status 1 and 2 indicate lands that are permanently protected from conversion and have mandated natural land management plans in operation. GAP status 3 lands have a degree of permanent protection from land conversion, but are subject to extractive use (like timber harvesting, ORV usage, or mining). GAP status 4 areas have no known permanent protections against land conversion.[6] The majority of IRC in the HCAs is in GAP 3 and 4 land, indicating that it is not fully protected. Much of Western HCA IRC is GAP 3, meaning that it is protected but still managed for resource extraction. The majority of IRC in Eastern HCAs is GAP 4, with no protections in place. A lower proportion of IRC is in GAP 1 and GAP 2 (Figure 5).

Vulnerability

The ecological and physical characteristics and ownership of IRC within each HCA largely determine its vulnerabilities. In Western

U.S. Region	HCA	Federal	State	Private	Other*
Western	Northern Rockies	66%	6%	23%	5%
	PNW	46%	8%	42%	3%
	Sierra	47%	1%	52%	0%
Eastern	Appalachia	7%	7%	84%	1%
	Carolina Coast	13%	8%	75%	3%
	Gulf Coast	4%	6%	89%	0%
	Northeast	6%	19%	69%	6%
Other	Alaska	50%	21%	23%	6%
	Northern MN / U.P.	8%	21%	68%	3%
	South Florida	44%	28%	22%	6%
*Other includes Tribal, NGO, Local, Jointly Managed, and Conservation District Land					

Table 1: IRC ownership by HCA across main owner types.

HCAs, the greatest threats are wildfire, followed by land conversion. In the Eastern HCAs, the greatest threat is land conversion and other climate impacts. In Appalachia and the Northeast, forests face the risk of logging and increased disease and insect infestations. In the Gulf and Carolina Coasts, peatlands and salt marshes face land conversion due to increasing population pressure. Sea level rise is also a major threat.

In Alaska, IRC is currently relatively well protected due to its large concentration in the Tongass National Forest and other state and federal land holdings and low wildfire risk. In South Florida, a large proportion of IRC is well-protected in the Everglades National Park, though land conversion remains a threat to state and private IRC. Sea level rise is also a significant concern in this region. In the Northern Minnesota and Upper Peninsula region, IRC is threatened by development of private land. Additionally, while there are carbon management plans focused on forests, the vast majority of IRC is in unprotected wetlands and peatlands, leaving it vulnerable to release through development and pollution.

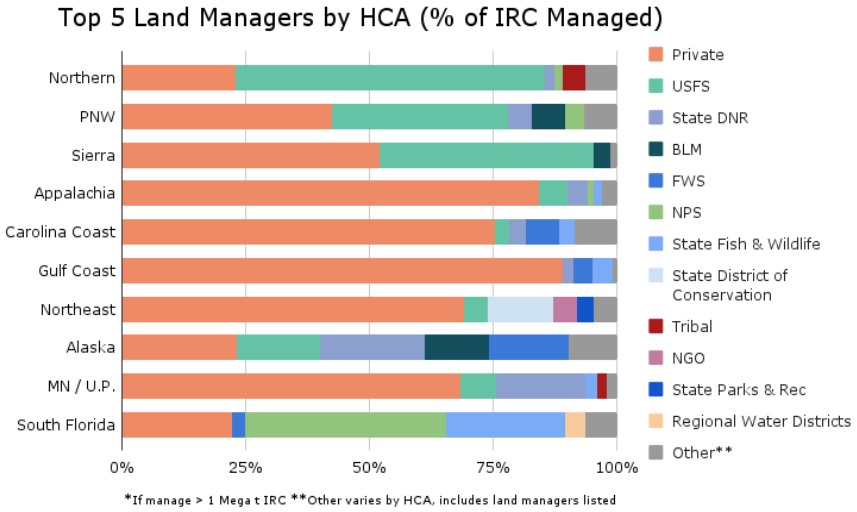


Figure 4: Top 5 Land Managers by HCA in terms of the percent of IRC managed, if they manage more than 1 megatonne IRC.

PATHS TO PROTECTION

Strategies for protecting IRC should be regionally specific and responsive to the cultural, ecological, and managerial dynamics of each area. That said, experts across regions suggested several common possible mechanisms for increasing IRC protection.

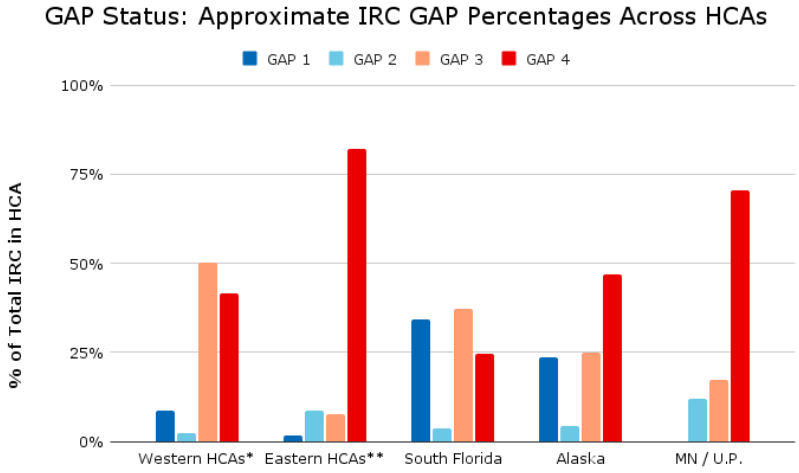


Figure 5: GAP status aggregated by HCA region. Outliers have been removed as follows: *Average of PNW, N. Rockies, & Sierra HCAs; outliers: Sierra GAP 1 status is less than 1% **Average of Appalachia, Carolina Coast, Gulf Coast, & Northeast; outliers: more Gap 2 land in Northeast and Coastal Carolinas HCA.

Many brought up carbon credits as a strategy for incentivizing land use decisions that prioritize carbon storage. While a promising concept, carbon credits are not yet responsive to ecological realities and have the potential to be incorrectly leveraged as evidence of carbon neutrality.[7] Thus more work is needed on this topic to determine how, if at all, they could be tailored to protect carbon already stored in ecosystems.

Tribal governments are already leading the way on exploring creative approaches to carbon conservation and incentivizing land stewardship that maximizes carbon protection. Initial research suggests that historical Indigenous land practices tend to increase ecosystem resiliency and, as a result, carbon storage.[8] Additionally, tribal groups are leading carbon credits for capture initiatives.[9] For example, the National Indian Carbon Coalition is an Indian-led non-profit that helps tribal nations utilize carbon credits.[10] They are partnering across nations and with large conservation NGOs like TNC to scale their efforts.

In the Western HCAs, increased IRC protection depends largely on more effective wildfire management. Thus, experts suggested several strategies for improving forest resilience to wildfire, including: collaborative stakeholder groups, increasing land management rights of tribal governments, increasing the use of prescribed fire, improving wood biomass processing infrastructure, and developing a larger forest management workforce able to thin and burn forests at the pace and scale needed. Working with the U.S. Forest Service – the largest land manager of Western IRC – is essential to addressing these needs at a large scale. To implement forest thinning at the pace and scale needed to protect IRC, the USFS should incorporate carbon as an explicit management goal and metric in forest plans,

Peatland ecosystem, MN - The Nature Conservancy.

Red Mangroves, FL - National Park Service.

leverage funding from the recently passed Infrastructure Investment and Jobs Act and Inflation Reduction Act to increase capacity for projects, and continue building partnerships with tribal and private land owners. Tribal governments have an increasing influence in land management decisions in the region; engaging them in IRC conservation efforts will increase the chances of success and the likelihood of lasting, equitable outcomes.

In Eastern HCAs, IRC protection depends largely on private landowners, some of whom are wary of government action. However, these landholders tend to have multi-generational ties to their land which can be leveraged when developing long-term, intergenerational conservation strategies. Additionally, intense climate impacts — such as damage from hurricanes or flooding — in this region have been successfully leveraged to encourage pro-climate behaviors and, by extension, can likely be used to encourage land protection. Strategic outreach and communication is essential. Residents value co-occurring ecosystem services such as storm protection and water filtration significantly more than climate mitigation. Thus, emphasizing climate resilience co-benefits of IRC protection rather than carbon storage itself could compel action by small and corporate landholders as well as regional governments.

Similar communication strategies are important for protecting vulnerable IRC in South Florida, though it is important to note that the region has a uniquely high degree of bipartisan support for conservation. Sea level rise in South Florida poses an existential threat to low-lying coastal areas. However, development remains the greatest threat to IRC. In the Northern MN / U.P. HCA, work with state-level resource agencies is needed to shift the focus from protecting forest carbon to instead making management plans and policies intended to protect wetland carbon. In Alaska, current protections must be monitored and defended if national-level politics shifts federal agency land use priorities and directives.

HCA PRIORITIZATION

Based on our analysis of HCAs, we prioritized HCAs for protection as seen in the chart to the right. However, our four priority memos focus on the HCAs that overlap with The Wilderness Society's priority landscapes.

HCA	Priority	Rationale
Appalachia	High	High amount of IRC; few protections; high vulnerability to conversion.
Pacific Northwest	High	High amount of IRC; high degree of threat; higher feasibility of protection.
Northern MN/U.P.	High	Relatively high proportion of private ownership; gaps in protection for wetland (e.g., soil) carbon.
Northern Rockies	Medium-High	High degree of threat due to wildfire.
Sierra	Medium-High	High degree of threat due to wildfire and development; however, low total amount of IRC.
Carolina Coast	Medium-High	High level of potential co-benefits; higher feasibility of protection; opportunity to engage with diverse stakeholders; low total IRC level relative to "High" Priority HCAs.
Gulf Coast	Medium-Low	Low feasibility of protection since population is not likely to support development limitations or creation of carbon markets.
South Florida	Medium-Low	Some vulnerability to development, but overall well-protected IRC in the Everglades National Park.
Alaska	Low	IRC is currently well-protected; "wait and see" approach: monitor federal land policy.
Northeast	Low	High proportion of existing protections; less severe threats.

High Carbon Area:

PACIFIC NORTHWEST

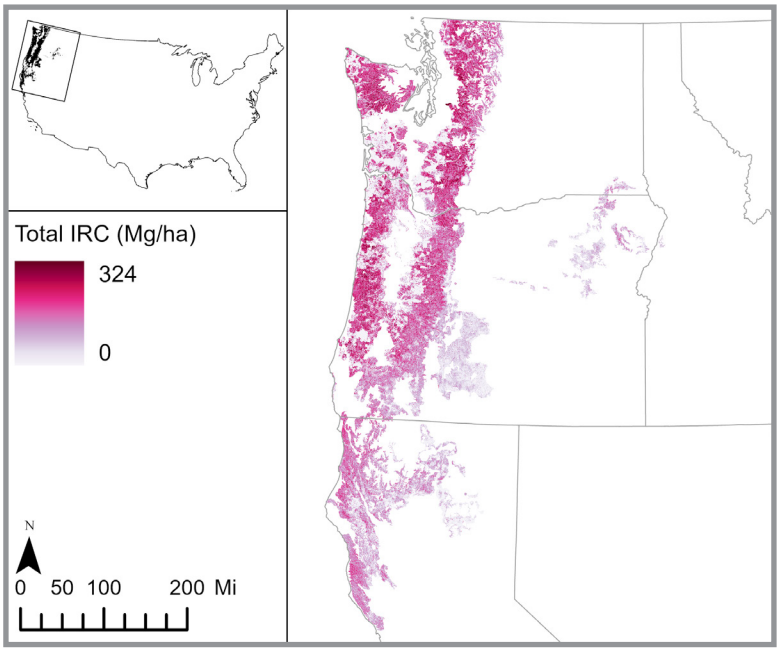


Figure 1: Total IRC in the Pacific Northwest HCA.

HCA GEOGRAPHIC AND CULTURAL CONTEXT

The Pacific Northwest HCA includes a large majority of western Washington (WA) and Oregon (OR), portions of northeast OR and northwestern California (CA). Indigenous lands – listed in order of most to least acreage – that currently overlap with this HCA include Quinault, Warm Springs, Hoopa Valley, Yurok, Yakama Nation, Makah, Round Valley, and Grande Ronde, among others.

The region fosters a significant outdoor recreation economy, contributing to 2.4%, 1.8%, and 1.6% of state GDP for OR, WA, and CA, respectively.[11] The growing number of outdoor recreationists has also built more support for improved management and conservation of connected lands, a movement which inherently increases protection of IRC. Politically, the broader PNW region leans left. In WA, 44% of adults identify as Democrat (or lean Democrat), while only 33% of adults in the state identify as Republican (or lean Republican). An even higher percentage of OR is Democratic, with 47% of adults identifying as Democrats (or lean Democratic). However, CA is more Democratic than both WA and OR with 49% of adults identifying as Democrats.[12] Despite the liberal politics in all three states, state-wide policies in the PNW region to comprehensively conserve IRC will require communities from both political affiliations to be engaged, heard, and incorporated into future regional action plans.

While the region's economy was historically dependent on logging, forest products are a declining part of the modern economy. However, this sector is still the most relevant and impactful to the protection of the IRC in the region, given that policies could exist to protect old-growth and mature forests while still allowing harvesting of younger trees to support the economy and that reductions in logging may open a possibility of leaving more areas unharvested. Even so, tree harvesting and carbon sequestration can co-exist, but management strategies will be key in making this successful. For example, four million acres of WA's 22 million acres of forest are privately owned, and 70% of WA's timber production comes from those private lands. WA State Department of Commerce (WSDC) states that 75% of the forests are less than a century old and half of the trees in the western part of the state are less than 40 years old, which is the ideal age for harvesting, but 30 years short of maximum carbon sequestration capability.[13, 14]

IRRECOVERABLE CARBON OVERVIEW

Ecological Characteristics

Most of this HCA is temperate forest (88.9% of the land area), with the remainder made up primarily of temperate grassland ecosystems (8.5%). The HCA holds over 1285 megatonnes of IRC, making it the third densest HCA of the 10 across the nation. 99.8% of that IRC is held in biomass and the remainder is sequestered in soils.

Ownership & Management

The majority of the IRC in this HCA is federally owned (46.3%). Of federal land, the U.S. Forest Service (USFS) manages 35.7% of acreage and the Bureau of Land Management (BLM) manages 6.8%. Notably, private land constitutes the second most land ownership type in

the region's HCA (42.4%). This suggests that policies and actions to increase IRC protection should focus on federal land (particularly USFS land) and private land.

As described above, the vast majority of the IRC in this area is locked in coniferous forests, and the majority of those forests are managed by the USFS or are private. On federal lands, management of these forests is guided by USFS forest management plans, the Northwest Forest Plan, and the Wilderness Act. Many of these plans discuss forest composition and vegetation's relation to carbon sequestration, but do not explicitly reference carbon storage as a rationale for management strategy.

A slightly different outlook is taken by tribal land management officials, who manage 1.5% of IRC in the HCA. Many, including the Nez Perce Forestry and Fire Management Division guiding statement, discuss protecting the intrinsic value of the forests. This definition may be broad and include a multitude of ecological and cultural factors, including carbon.

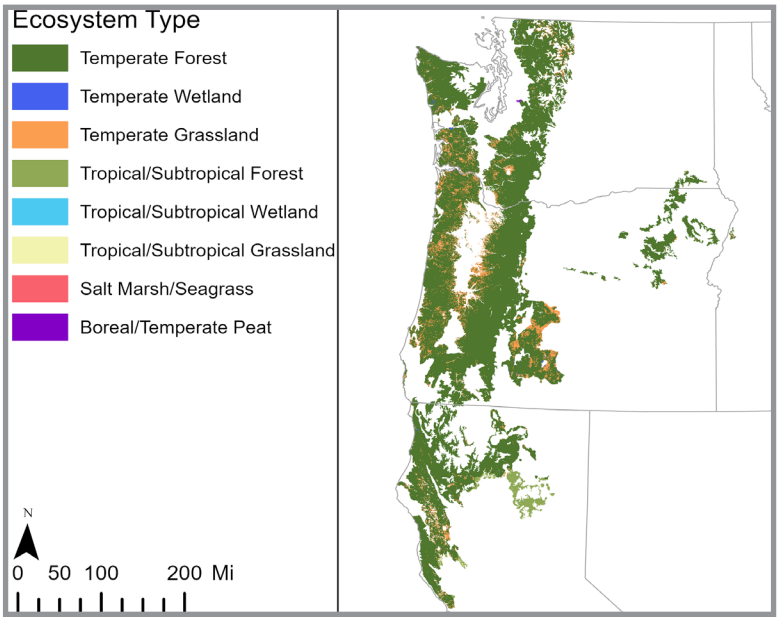
Glacier National Park is the only NPS land within this HCA, and neither the 1999 General Management Plan and EIS summary discussing environmental consequences, nor the revised 2010 Fire Management Plan even mention the word "carbon."

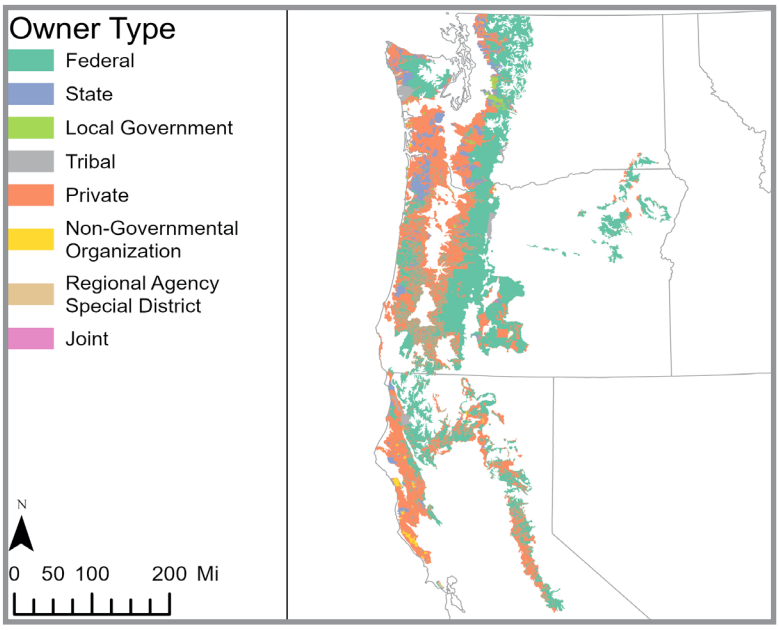
IRC PROTECTION & THREATS

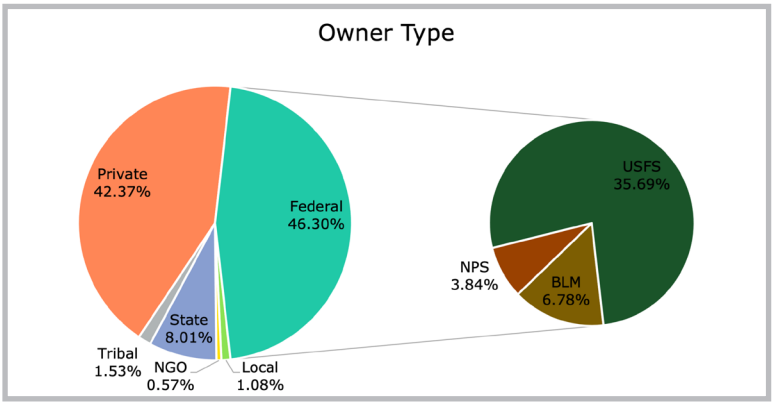
Approximately 13% of the IRC is currently protected from development as defined by GAP status; this portion has a GAP status of 1 or 2. An additional 42% of the total IRC is GAP 3 land and is subject to extractive uses such as logging and mining. Because a significant portion of the IRC in the HCA is on USFS land, the primary mechanisms of protection are the Wilderness Act and forest plans set parameters for management of large portions of the forest in ways that prohibit undue human influence.

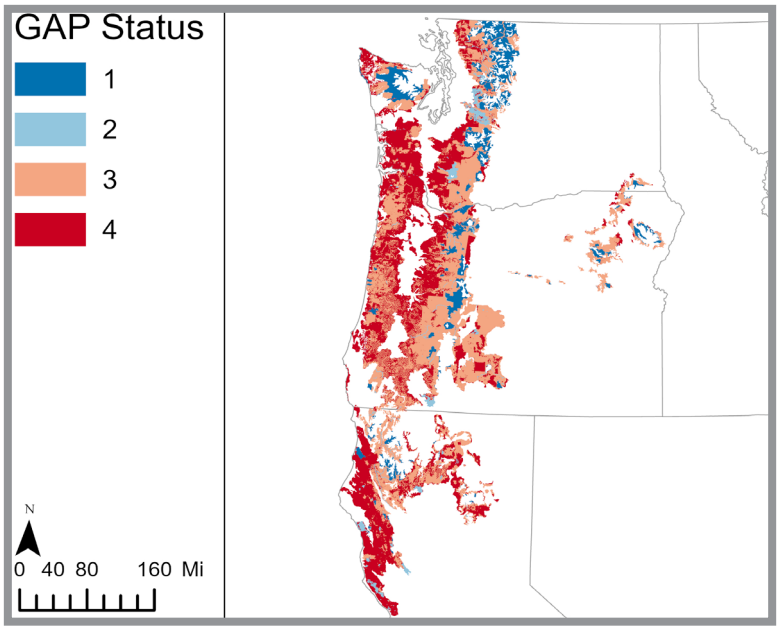
Federal laws such as the Farm Bill and the recent Inflation Reduction Act (IRA) also provide incentives for conservation practices in agriculture and land management. The IRA gives $5 billion to the USFS to improve U.S. forest health, protect communities from wildfire, reduce fuel load and support small forest landowners in mitigating climate change. Under Subtitle D, Section 23001 of the IRA, $2.15 billion are allocated for tasks (i.e., hazardous fuel reduction and old growth forest protection) that reduce wildfire risk and subsequently protect

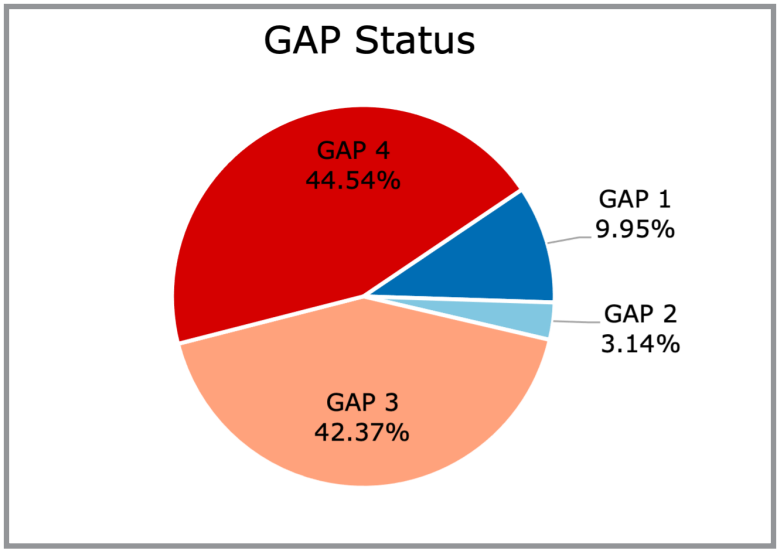
Top - Figure 2: Ecosystem of IRC in the Pacific Northwest; **Middle - Figure 3:** Owner type of IRC in the Pacific Northwest; **Bottom - Figure 4:** Owner of IRC with federal ownership split into agencies.











Top - Figure 5: GAP Status of IRC in the Pacific Northwest; **Bottom - Figure 6:** Breakdown of GAP Status of IRC in the Pacific Northwest.

IRC.[18] Provisions in the Farm Bill support forestry management programs that are run by the USFS.[19]

Under the Farm Bill's Forestry Title, resources are allocated to remove forest biomass on federal and nonfederal lands to prevent high-intensity wildfires.[20] Areas supported by this treatment will have less fuel loads and lower risk for large scale fires that would otherwise release IRC.

However, significant portions of IRC remain unprotected, as about 44.5% of the IRC in this HCA has no known mandate for protection under GAP status 4. These findings suggest that a significant amount of the HCA land in the PNW is not managed for the protection of biodiversity or carbon. Population growth in the region has accelerated development, threatening forests and wildfire risk. For example, in WA and OR the area of the wildland-urban interface (WUI) (in km) has increased from 6.1% to 8.2% and 3.0% to 3.8% of the state, respectively.[21] It should be noted that under the current OR Urban Growth Boundary (UGB) Laws, urban and suburban development has historically been more limited across the state, the WUI. While the whole HCA faces the challenge of population growth, WA in particular is extremely susceptible given its comparably laxer UGB laws.[15]

Such findings demonstrate the need for management that incorporates biodiversity and conservation into decision making. Ideally, GAP 3 and 4 landscapes would be managed as 2 or 1. Increased levels of biodiversity and a healthy ecosystem support greater levels of carbon storage in biomass as a result of increased photosynthetic inputs. Consequently, more ecologically complex systems with higher diversities of flora and fauna lead to greater levels of overall carbon sequestration significantly contributing to natural climate solutions.[16]

Within this HCA, wildfire and land conversion – primarily in WA – are the largest threats. Under the NW Forest Plan protections, the heaviest logging operations shifted from USFS land to state and private managed areas. Consequently, wildfire remains the primary threat to IRC located on USFS managed lands. Development, a product of the increasing population boom in the region, is significantly intruding into nearby forest land and threatening ecosystems high in IRC, however, wildfire is the primary vulnerability of the IRC across the PNW. Reduced snowpack, historic droughts, and a warming global temperature have made this area's IRC extremely vulnerable to release via high intensity wildfire disturbance. By 2050, WA is expected to see an increase in over 300% in the severity of summer drought.[17] While most wildfires are caused by human activity, the most destructive fires tend to be naturally caused in remote areas. Because these epicenters for fire are quite inaccessible (such as is the case on many federal public lands), firefighter teams have trouble combatting the flames and preventing them from spreading rapidly. Logging on private, state, and federal lands also poses a threat to IRC, especially as management practices aren't optimized for ecosystem connectivity and health.

PATHS TO INCREASED PROTECTION

Because much of the Pacific Northwest has been subjected to land conversion (largely for agriculture, agroforestry, and development), increasing sustainable management and reducing future conversion will be key. Statutes such as the IRA and bills in progress, such as the Wildfire Emergency Act, create federal-level incentives and capacity for improving forest management and long-term planning around conservation and fire management, bolstering activities in support of forest restoration, wildfire mitigation, and energy resilience.

Another opportunity highlighted by interviewees lies in implementing more tribal co-management or complete transfer of management to Indigenous groups. This would not only return land and land management decision making to traditional stewards, but will also help decrease pressures of management and resources on federal agencies, help Indigenous groups retain old treaty rights, and increase collective management capacity to more effectively mitigate high-intensity wildfires.

One challenge will be confronting the increased need for space and wood products with population rising in the region. Changing development regulations – such as increasing regulations like OR's UGB laws – to increase high density housing and improve private land management for carbon sequestration. Increasing community education as well as expanding forest collaboratives offers a solution to include new and diverse stakeholders and perspectives.

Recent polling and policy changes suggest that there is significant public support for forest restoration and climate action.[22] The majority of respondents (over 50%) in these three states all claimed that they believe the President, Congress, their Governor, and local officials should all do more to address global warming. These regional findings are encouraging understanding that increasing concerns for action on climate change can precipitate more proactive climate policies that end up protecting IRC. Not unlike regional views on climate change, an expert from the region described how the majority of the populations in the PNW see wildfire as a major problem and risk (regardless of political leaning).[23] This overall sentiment has led to the passage of legislation aimed at mitigating high-intensity wildfires in the PNW. In 2021, both WA and OR passed key bills (e.g., WA House Bill 1168, and OR Senate Bill 762) with bipartisan support aimed at restoring state forests and reducing wildfire occurrence. As regional fires and community vulnerability continues to worsen, PNW populations may be open to yet more proactive climate or federal policies that indirectly preserve IRC.

Increasing community engagement can then encourage locally driven conservation projects which can be expanded using grant programs such as the America the Beautiful Challenge that offers dedicated funding to locally-led landscape-scale conservation and restoration projects that implement existing conservation plans. In 2023, the program will award up to $116 million and will prioritize Indigenous-led projects. With time, there are also increased market opportunities for carbon markets in the Northwest that offer potential incentives for private landowners to increase protections even beyond conservation easements. Under the New Farm Bill, there are continual discussions to expand the development of wood products via woody biomass that has been acquired via fuel reduction strategies in forest.[24] Additionally, there are pushes in WA to establish a carbon crediting system. Via HB 1789 - 2023-24, which passed in the House, activities benefiting ecosystems via habitat restoration, protection and management would generate credits. These credits could then be sold back to polluters attempting to offset their emissions as they decarbonize over time under Washington's Climate Commitment Act.[25] With proper regulation of the market to ensure there are overall reductions in carbon emissions for companies in spite of credit purchases, IRC can be preserved under the many management activities that would be produced from this bill.

Another management improvement that would expand protection would be to incorporate and weigh different planning metrics from those used currently. Switching focus from emphasizing property protection to ecosystem connectivity, long-term resilience, and balancing human-nature interactions would allow the HCA to take steps to better protect from catastrophic wildfire, increased development, and ultimately, reduce the potential loss of IRC.

A major recommended fuel reduction strategy to protect IRC for forest managers is the use of prescribed fire. Under controlled and proper conditions, prescribed fire can burn through forest floor vegetation clearing out debris that has accumulated overtime. This treatment counteracts fuel buildup and emulates natural forest fire regimes that have been suppressed under previous land management plans. Prescribed fire treatments mitigate high-intensity fire risk as fuel loads in treated areas are low, preventing any new fire from escalating into a conflagration that would release large quantities of IRC.[26] Not only can prescribed burns prevent the extensive release of carbon (including IRC), but they can also prevent the killing of local biota in catastrophic numbers and prevent ecosystem alteration due to otherwise often irreparable fire damage.

There are several limitations to prescribed fire implementation (e.g., dry conditions, little precipitation, high winds, no ground snow, little public support, administrative barriers, lack of available trained personnel), that significantly reduce the feasibility of conducting the treatment to the scale necessary for proper IRC protection. It is therefore recommended that prescribed fire be supplemented by a variety of natural resource approaches (e.g., selective logging, biomass removal, slashing, chipping, thinning, burn piles) to reduce fuel load.[27] Many of these natural resource strategies encounter less opposition from local communities and can act as more reliable year-round strategies when regulated properly. For USFS managers, a combination of prescribed fires when possible, and natural resource management mechanisms will be required to most effectively reduce fuel loads and mitigate the threat of IRC release.[28]

High Carbon Area:

NORTHERN ROCKIES

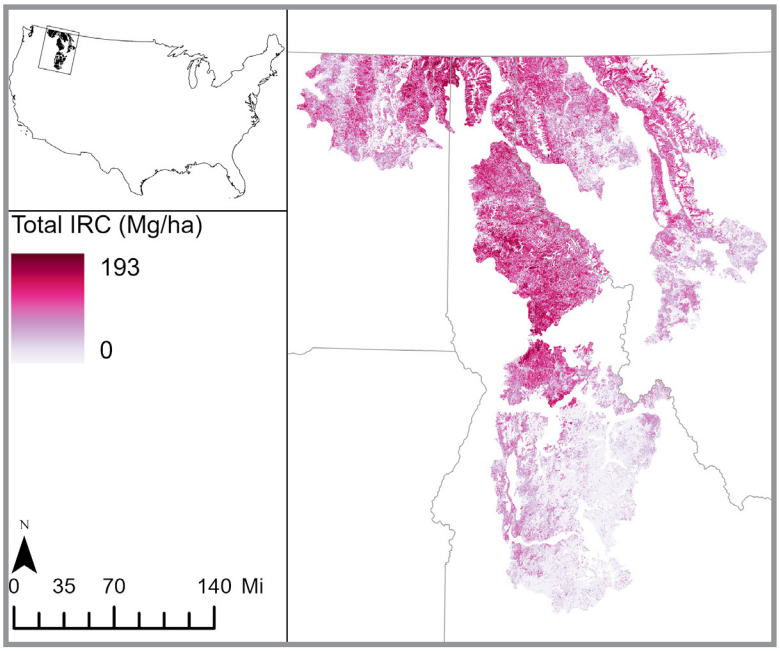


Figure 1: Total IRC in the Northern Rockies HCA.

HCA GEOGRAPHIC AND CULTURAL CONTEXT

The Northern Rockies HCA includes the coniferous mountain forests of Northeast Washington, Mid- to Northern Idaho, and Western Montana. This land is the ancestral and present-day land of the Shoshone, Blackfoot, Colville, Spokane, Coeur d'Alene, Flathead, and Crow, Salish & Kootenai Indigenous Peoples, among many others. This region – especially its rural communities – has historically been economically dependent on its forests, with logging driving much of the original colonial settlement. However, the economic picture of the region is shifting. Timber production has decreased from 31% of labor income to 11% from 2000 to 2016 in Montana.[29] In 2019, the GDP contribution of timber products in Montana was $348 million, and $853 million in Idaho. By comparison, outdoor recreation contributes $2.5 and $2.8 billion dollars into Montana and Idaho's annual economy, respectively.[30, 31] Other important industries include the services industry, agriculture, mining and manufacturing, and other extractive industries.[32]

While the Northern Rockies HCA includes and borders larger population centers in the region, including Boise, ID, Missoula, MT, and Spokane, WA, it is predominantly made up of rural areas. Therefore, the HCA contains and is surrounded by low population density counties, with the majority having less than 50 persons per square mile.[33] Despite the low population density, the population across the HCA has been rising, leading to an expanding wildland-urban interface (WUI), habitat fragmentation, and increased risk of carbon release. For example, "The close proximity of houses and wildland vegetation does more than increase fire risk. As houses are built in the WUI, native vegetation is lost and fragmented; landscaping introduces nonnative species and soils are disturbed, causing nonnatives to spread…" and overall landscape disturbance.[34]

Politically, the area leans heavily right, with most elected officials belonging to the Republican party. While this tends to limit climate-specific related policies from gaining popular support, regardless of political affiliation, recent polling has found that the majority of voters in the region support broad conservation goals such as "ensuring healthier forests…and safeguarding drinking water."[35] Given this, efforts to protect IRC will require communication around relatable co-benefits to garner support.

IRRECOVERABLE CARBON OVERVIEW

Ecological Characteristics

This HCA is comprised of three main ecosystem types, temperate forests, wetlands, and grasslands. Over 85.5% of the HCA area is forested, dominated by mountainous coniferous forests, while 14% is grassland and the remaining 0.4% is wetland. The IRC in this HCA is primarily found in biomass (99.9%) and the region holds over 450 megatonnes of IRC, ranking eighth highest in density of IRC of the ten HCAs. The region's forests and other public lands are known to provide ecosystem services including water filtration, outdoor recreation, forest products, and livestock grazing. The national forests in particular provide landscape connectivity that benefits biodiversity and wildlife health.[36]

Ownership & Management

The majority of the IRC in this HCA is federally owned, specifically by the United States Forest Service (USFS), which owns 62.7%

of IRC in the HCA. A significant portion of IRC is owned by other agencies and entities as well, including 5.9% owned by state agencies, 4.5% by tribal entities, 1.8% by the National Park Service (NPS) 1.2% by the Bureau of Land Management, and 22.9% privately owned. The vast majority of the IRC in this area is locked in mountainous coniferous forests, and the majority of those forests are managed by the USFS. Management of these forests is guided primarily by several USFS forest management plans including the Idaho Panhandle, Nez Perce-Clearwater, Kootenai, Payette, Lolo, Bitterroot and Flathead national forests. Some of these plans discuss forest composition and vegetation's relation to the ecosystem service of carbon sequestration, but do not explicitly reference carbon sequestration as a rationale for management strategy.[37, 38]

The state land in the Northern Rockies is minimal, with some land managed via state parks in Montana, Idaho, and Eastern Washington. There is no available documentation that suggests any of the state land in this HCA is being managed with consideration given to carbon sequestration.

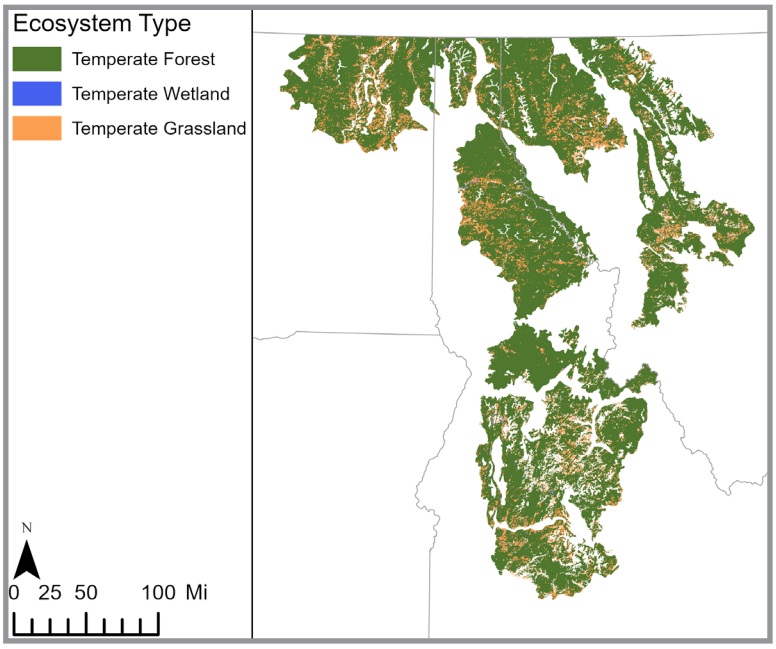
A slightly different outlook is taken by tribal land management officials. While carbon is not explicitly mentioned in any guiding managerial documents, many, including the Nez Perce Forestry and Fire Management Division guiding statement, discuss protecting the intrinsic value of the forests. This definition may be broad and include a multitude of ecological and cultural factors, potentially including carbon sequestration.

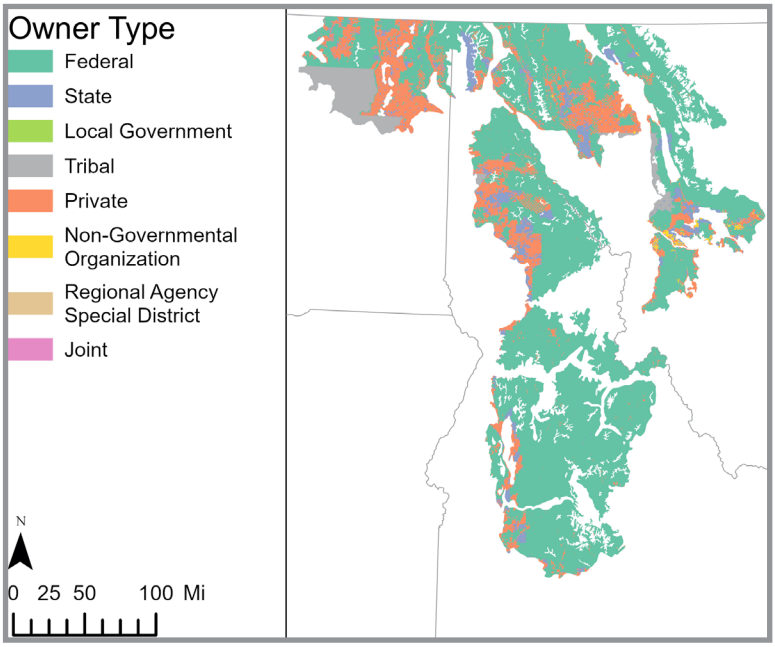
Glacier National Park is the only NPS land within this HCA, and neither the 1999 General Management Plan, EIS summary, and volume with environmental consequences, nor the revised 2010 Fire Management Plan mention the word "carbon."[39, 40]

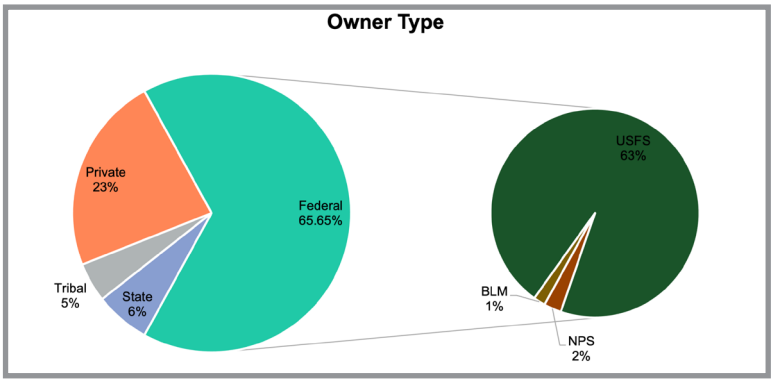
IRC PROTECTION & THREATS

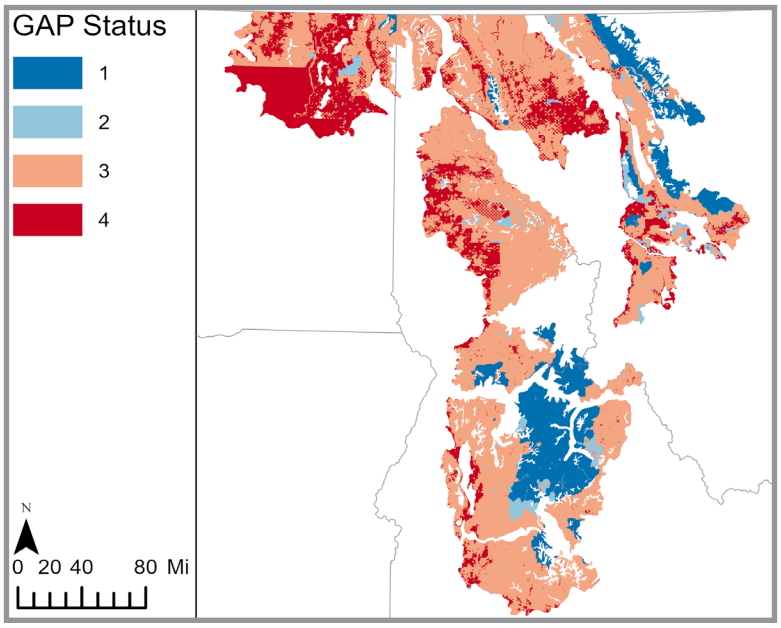
Within this HCA, 10% of the IRC is currently protected permanently from conversion under GAP status 1 or 2. Although an additional 62.4% of the total IRC is GAP 3 land – indicating protection for the majority of the area – this land is subject to extractive uses such as logging and mining. Because much of the IRC in the HCA is on USFS land, the primary mechanisms of protection are the Wilderness Act and forest plans that manage large portions of the forest in ways that prohibit undue human influence. For example, the Bob Marshall Wilderness Complex in Montana protects an

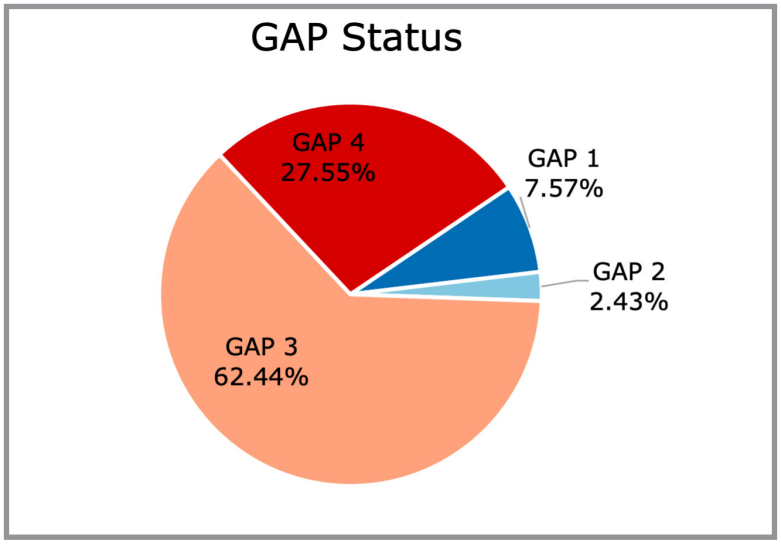
Top - Figure 2: Ecosystem of IRC in the Northern Rockies; **Middle - Figure 3:** Owner type of IRC in the Northern Rockies; **Bottom - Figure 4:** Owner of IRC with federal ownership split into agencies.











Top - Figure 5: GAP Status of IRC in the Northern Rockies; **Bottom - Figure 6:** Breakdown of GAP Status of IRC in the Northern Rockies.

area of over 1.5 million acres, the third largest in the lower 48 states.[50]

Currently, there are ongoing efforts to expand protections of IRC in the Northern Rockies HCA. A portion of the IRC in the HCA was being considered for increased protection via H.R. 1755 and S.1276, the Northern Rockies Ecosystem Protection Act, during the 117th Congress, which was most recently reintroduced in 2021.[51] The expectation is that a similar piece of legislation that would designate specified National Forest System lands, NPS lands, and public lands in the West – including 9.5 million acres in Idaho and 7 million acres in Montana – as wilderness will be reintroduced in the 118th Congress. While the bill has been unsuccessfully introduced six times since 1993, it has received support from several NGOs including Alliance for the Wild Rockies and Sierra Club and has been updated to reflect current needs.

Significant portions of the IRC in the Northern Rockies HCA remain unprotected. Approximately 27.6% of the IRC has no known mandate for protection under GAP status 4. Increasing populations in the region have accelerated development; between 2020 and 2021, Idaho experienced the fastest annual population growth among states in the US, and Montana's growth – 1.6% – also exceeded the national average rate of 0.1%. Much of this growth occurred in rural counties in western Montana.[41] With increased population in the region, increased land conversion for development, especially in more rural areas where development is significantly intruding into nearby forest land makes IRC in these areas particularly vulnerable.

Nationwide trends reflect a 44% increase in homes in the WUI from 1990-2010. In Idaho, FEMA estimates that 30.1-40% of homes exist in the WUI.[42] These numbers are supported by a 2022 study by Radeloff et al.[43] According to that study, the majority of homes in Montana (62.4%) exist in the WUI, a number that has increased 2% over the past 30 years. Homes in the non-WUI experienced a simultaneous 2% decrease in that same time period, from 39.1% to 37.6%. In the state of Washington, both WUI (32.5%) and non-WUI (67.5%) housing percentages have stayed flat.[44]

The primary vulnerability of the IRC in this area is wildfire risk. Reduced snowpack, historic droughts, and a warming global temperature have made this area's IRC extremely vulnerable to release via wildfire. By 2050, Idaho's average number of days with high wildfire potential is projected to quadruple from fewer than 5 days to 20 days per year.[45] Similar trends are found in western Montana; the state has seen a larger percentage increase in the number of large fires than any other western state over the past 45 years.[46] Regardless of administrative protections, wildfire will continue to be a large risk. Given this, proactive fire management is a key to protecting ecosystems in this HCA.

PATHS TO INCREASED PROTECTION

Comprehensively addressing the increasing wildfire threat is a large task that has benefits far beyond IRC protection. An approach that has gained support in the region is that of a year-round fire strategy that involves increased off-season mitigation and tribal leadership in land management decisions. An example of this is the collaboration between the Forest Service and the Confederated Salish & Kootenai tribe of Montana. This collaboration leveraged Tribal Forest Protection Act authority and Reserved Treaty Rights Land fuels reduction funding, allowing the tribal managers and fire crews to actively manage non-reservation lands, applying traditional Indigenous knowledge and conserving culturally important landscape, to the mutual benefit of both parties.[47]

While people in the region are aware of direct impacts of fire, there should be an increased emphasis on voter understanding and engagement on the benefits of fire as a management tool as well as on the role of carbon sequestration and protection in their lives and livelihoods. By garnering support from community members and communicating clearly the need to increase protections with actions such as prescribed burns, there is a higher likelihood of more successful fire management plans and decreased development in wildland-urban interfaces.[48]

Similar to strategies in the Pacific Northwest, there could also be preemptive action taken to influence development, especially in areas seeing booms in population. Combining public education with clear zoning provisions guiding building materials and fire-safe approaches will be key to not only building resilient communities but also garnering public support for conservation efforts.

Regulatory approaches to increasing protections, such as the Northern Rockies Ecosystem Protection Act, as well as supporting increased funding to land management agencies (as was provided in the Bipartisan Infrastructure Law and the Inflation Reduction Act) will provide opportunities for agency focus on improved forest management for fire reduction as well as IRC protection. As one interviewee discussed, "forest plans and resource management plans are the most effective ways we currently have to protect [vulnerable] areas, in large part due to the emphasis on public partnership."[49]

The same interviewee discussed the importance of working with private landowners, land stewards, and land trusts to help increase overall land protections and engage in co-management strategies. They used examples throughout their career that illustrate how much more likely a project is to succeed and to maintain long-term support when public participation has been emphasized, and all stakeholders have been welcomed to the collaborative process for land management. Emphasizing and reinforcing this practice is critical in strengthening IRC protection in privately held land areas that abut well-protected lands under federal management. Given this, enabling land management agencies to take more preventative measures in forest plans by pushing public support for IRC protections and proactive fire management will be a crucial step in changing and improving management for the benefit of the region.

Glacier National Park, courtesy of NPS - Flickr Creative Commons.

High Carbon Area:

THE SIERRA

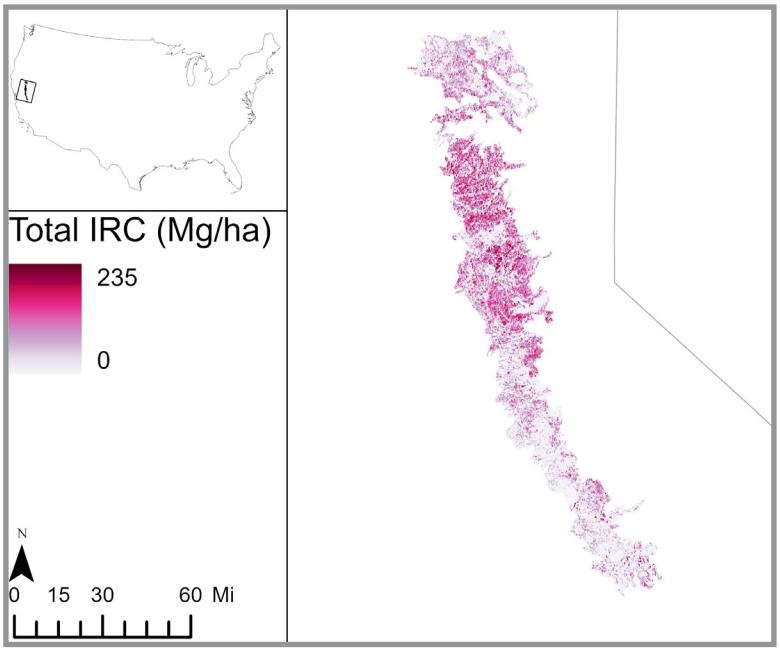


Figure 1: Total IRC in the Sierra HCA.

HCA GEOGRAPHIC AND CULTURAL CONTEXT

The Sierra HCA is located on the Western side of the Sierra Nevada Mountains. Federally recognized tribes in the HCA include: Enterprise, Berry Creek, Mooretown, Shingle Springs, Jackson, Sheep, and Tuolumne Tribes.[52] The HCA overlaps with the Southern tip of the Lassen Volcanic National Park, western portions of the Plumas, Tahoe, Eldorado, and Stanislaus National Forests, and the northwest corner of Yosemite National Park.

The Sierra HCA is relatively unpopulated; the 10 counties it overlaps have densities of 99.9 or fewer people per square mile.[53] Much of the population lives at the Wildland Urban Interface (WUI).[54] Four counties are 80% white or higher, with the remaining six counties at over 60% white.[55] In the 2022 race for governor, the area voted majority Republican with the exception of Nevada County where Gov. Newsom won narrowly. Placer and Butte Counties had narrower margins, with at least 40% of the population voting Democrat.[56]

IRRECOVERABLE CARBON OVERVIEW

Ecological Characteristics

The Sierra HCA contains approximately 31 Mt of IRC and has the 2nd smallest density of IRC by acre amongst the HCAs (at 13.47 Mg / acre). IRC in the Sierra region is primarily stored in temperate coniferous forests, including the charismatic redwoods. Almost 100% (30.8 megatonnes) of the IRC is stored in plant biomass (trees, roots, foliage) with a relatively miniscule amount (0.01 megatonnes) stored in soil. The ecosystems high in IRC are fire-adapted and require regular thinning to maintain resilience.[57] Regional experts emphasized the dynamic nature of carbon in the area and the importance of maintaining the carbon flux, rather than a static level of carbon storage.[58]

IRC Co-Benefits

Regional experts most frequently highlighted watershed protection as a compelling co-benefit of IRC in the region.[59] Recreation and cultural sites also provide a multitude of ecosystem services to locals and visitors – the HCA includes several National Forests, includes the popular Tahoe region, and is adjacent to Yosemite National Park.[60]

Ownership and Management

IRC ownership in the Sierra is nearly evenly split between federal (47.2%) and private ownership (52%). Less than 1% of IRC in the Sierra HCA is owned by Tribal, State, or Local governments.

The United States Forest Service (USFS) manages around 43% of Sierra IRC, while private entities manage around half of the IRC. The Bureau of Land Management (BLM) is the next largest land manager, but oversees less than 5% of the IRC in the area – and thus

has significantly less influence over IRC protection. Federally recognized tribes manage only .002% of the IRC in the HCA. However, the HCA contains the historic ranges of 10+ tribes, and is the site of several unratified tribal treaty lands – thus tribal perspectives should be prioritized in conservation efforts throughout the region.[61,62]

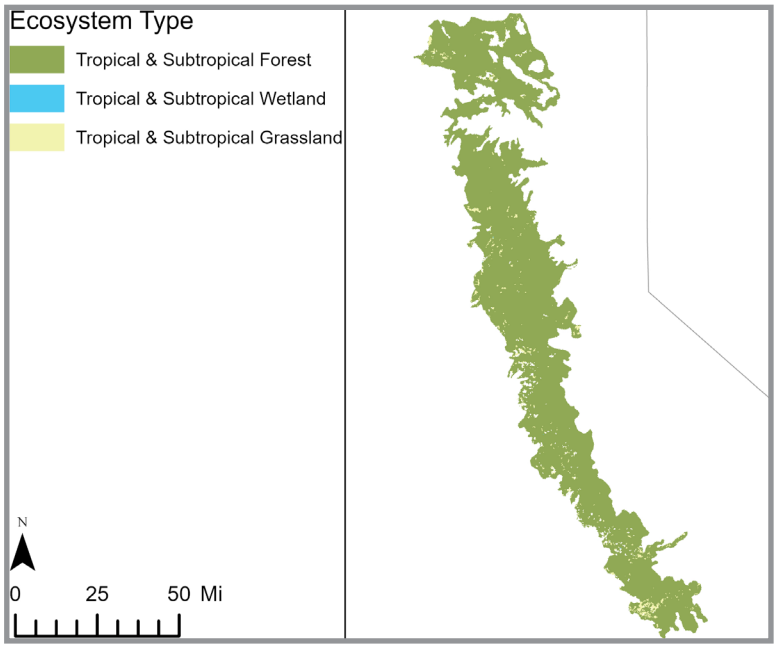
IRC PROTECTION & THREATS

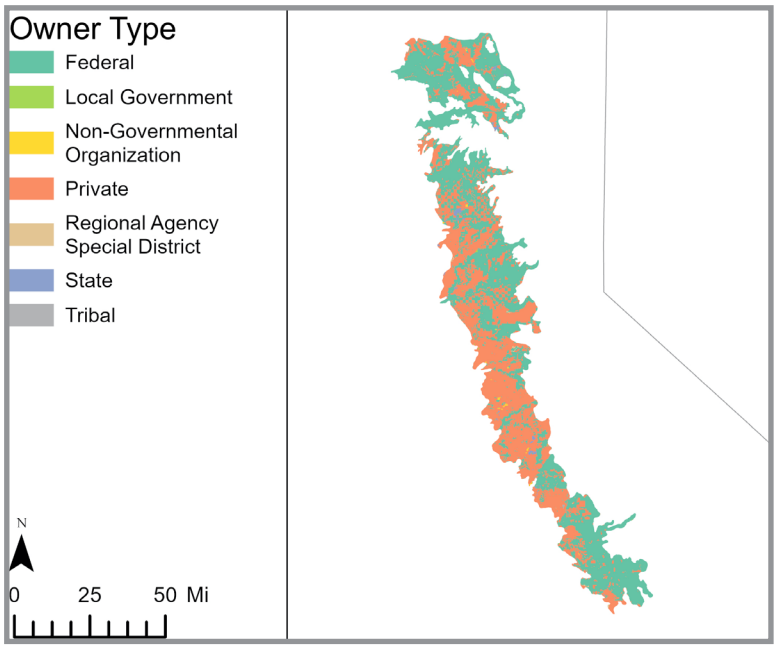
The majority of the Sierras IRC is Gap 3 (45.8%) and Gap 4 (52.7%), with less than 2% designated Gap 1 and 2 land. Nonetheless, regional experts emphasize that wildfires are the greatest threat to Sierra IRC protection. As a regional conservation expert stated: "You can protect a whole lot of old growth forests... and [they] can burn down in one season...It will take hundreds of years to get back to that condition again."[63] The risk of land conversion and logging is a lesser concern. One expert indicated that laws such as the Endangered Species Act adequately protect the oldest, highest carbon forests in the region via spotted owl protection.[64]

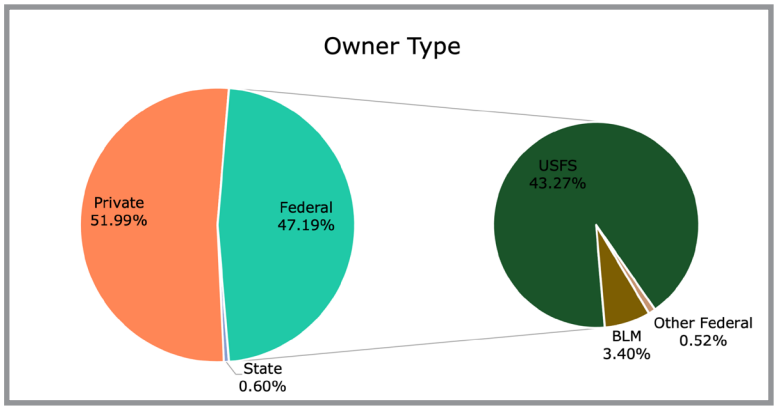
The risk of wildfire is accelerated by climate-related drought and beetle infestations, which are making forests more likely to burn. According to one regional scientist, "1.5 million trees were lost in the 2012 drought in the Sierras...due to the 'one-two punch' of drought and beetles".[65] These factors influence wildfire severity, which plays a large role in the amount of carbon released. "The fire itself does not influence the carbon storage in the moment," said one expert, "it's what happens after the fire in the next 10 to 40 years that matters most."[66] Further, the growing Wildland-Urban-Interface (WUI) population is increasing wildfire risk. In the WUI, the intermixing of human structures and fire-adapted forest increases ignition risk and makes wildfire management more complicated due to the need to protect humans and assets rather than just the forest.[67]

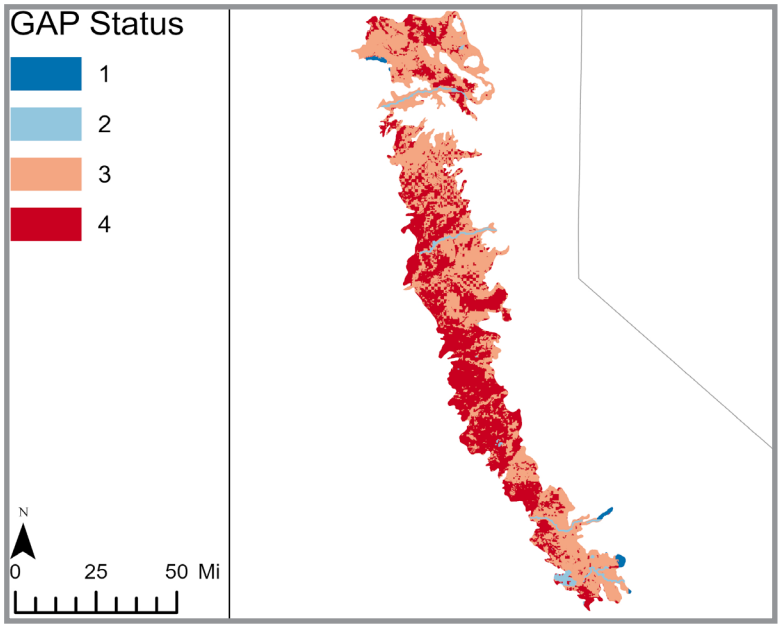
While the risks to Sierra IRC are daunting, the state of California is leading the way on making carbon conservation an explicit management goal, particularly in the context of wildfire management. "The Sierras were ground zero for carbon management," said one regional ecologist.[68] In 2018, a multistakeholder climate action team with representatives from the Governor's office, several state agencies, the USFS, local conservation groups, and rural counties authored the California Forest Carbon Plan. The plan addresses the risk of CA forests becoming greenhouse gas sources and outlines a cross-boundary ecological,

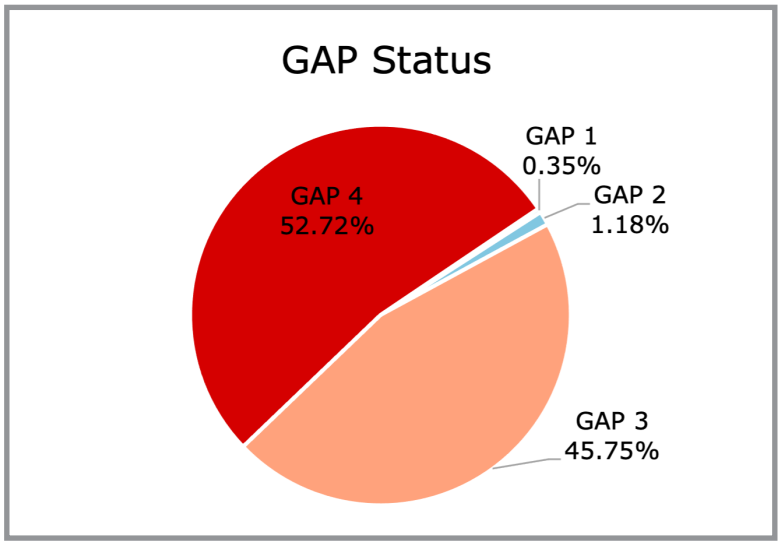
Top - Figure 2: Ecosystem of IRC in the Sierra; **Middle - Figure 3:** Owner type of IRC in the Sierra; **Bottom - Figure 4:** Owner of IRC with federal ownership split into agencies.











Top - Figure 5: GAP Status of IRC in the Sierra; **Bottom - Figure 6:** Breakdown of GAP Status of IRC in the Sierra.

economic, and governance strategy for conserving carbon across the state.[69]

The CA Forest Carbon Plan is just one example of efforts underway in the state. A $1.2 billion wildfire resilience package for 2022/2023 passed the legislature and the state has had a carbon cap-and-trade policy since 2013 with environmentally-designated auction revenues.[70] The latter has funded work by Calfire to implement treatments that reduce fire intensity, crowning potential, and general resistance to future fires.[71] Additionally, significant federal wildfire restoration funds are entering the state due to the Infrastructure Bill and the Inflation Reduction Act.[72]

The economic and planning efforts are valuable, yet capacity to implement necessary forest treatment remains a challenge. Narrow burning windows, equipment shortages, and lack of staff make meeting CA's ambitious thinning target of 500,000 acres thinned per year by 2025 nearly impossible.[73] Further, public resistance towards lower density forests and/or poor air quality due to prescribed burns can slow project implementation.[74] Further, while the USFS references elements of carbon storage in their forest plans, it does not list carbon protection as an explicit goal.[75] All these factors reduce the effectiveness of current land management efforts designed to enhance carbon storage protection – as a result, IRC in the Sierra remains quite vulnerable to release.

PATHS TO INCREASED PROTECTION

Actions for Increasing Effectiveness of Carbon-Based Land Management

The ideas below were raised in expert interviews as strategies to increase the regional focus on carbon protection.

Expand and Add Ecological Nuance to the Carbon Market

Experts see the carbon market as a valuable tool for IRC protection, either via payments to landowners for carbon conservation (e.g., the USDA Conservation Reserve Program), auction revenues from the cap-and-trade policy, or other carbon finance initiatives.[76] However, the market needs to become more responsive to regional forest ecology. Increasing evidence suggests that old growth forests have significantly more stable carbon stores than younger, densely planted forests; however, the carbon credit market does not yet reflect that reality.[77] "Carbon carrying capacity" could be used to differentiate carbon investments by the degree of stability in a given forest, based on the size and species of its trees.[78]

Ensure Carbon is Explicitly Included in Forest Planning

While California leads the way on creating a carbon credit marketplace as well as prioritizing carbon storage, national forest plans need more targeted planning about which forms of carbon are most important to conserve and what constitutes a healthy carbon flux. In conjunction with carbon credit programs, education and outreach should target private landowners to help them understand how to promote long-term carbon protection via land management and possibly gain carbon-linked revenues as well.

Possible Wildfire Management Actions

To increase IRC protection conservation groups and land agencies must focus on how to restore forests to a fire-resilient state, before expanding land protection. Most suggestions for creating greater wildfire resilience involve increasing capacity to treat forests at the pace and scale needed.

Leverage Federal Funding and Expand Capacity for Forest Restoration

Recent policies, such as 30 by 30, offer an opening to gain federal support for expanded landscape protection. Further, funding from the Infrastructure Bill (IIJA) and Inflation Reduction Act (IRA) should be captured and directed towards carbon management and wildfire fighting efforts. Additionally, the multi-year NEPA Environmental Impact Statement (EIS) process should be reevaluated and streamlined to reduce USFS project implementation delays.[79]

In order to effectively use government funding coming from the IIJA and the IRA, greater forest treatment capacity is needed. The region needs mills, equipment, and a skilled labor force.[80] "How many chainsaws do we have and how many do we need? These are things we are working through right now," said a forest and fire conservation expert from the region.[81] Additionally, Fire Science Consortiums and additional research on which logging practices most increase forest resilience, while being economically viable, would increase carbon storage.[82] Taken together, efforts to increase capacity will make Sierra IRC more resilient to wildfire, and thus better protected from release.

Increase Tribal Government Capacity and Use of Prescribed Fire

In recent years, a movement to reinvigorate Indigenous land management has grown based on a desire to reverse the impacts of colonialism, an understanding that it restricted ecologically (and culturally) valuable practices, and the recognition that years of fire suppression have contributed to megafires.[83] There is compelling evidence that prescribed burning protects forests and human resources; for example, in the 2021 Caldor fire, a 3000 acre prescribed fire area reportedly protected a town and reduced the use of firefighting resources due to the increased resilience it conferred to the forest.[84] Thus, working with tribes (both federally recognized or not) to understand the resources they need to reinstate burning and other forest management practices across their ancestral homelands will contribute to increased Sierra IRC protection.

Support Local, Collaborative Efforts and Public Education to Protect CA Forests

Forest collaboratives and partnerships – multi stakeholder groups that find consensus on public forest projects or private/public forest restoration efforts – have had success increasing forest resilience to wildfire through their work.[85] For example, the diverse Dinkey Collaborative in the Sierra National Forest has leveraged partnerships to implement forest treatments and expand the restoration workforce and economy.[86] Several regional experts recommended further supporting these groups via grants that already exist - such as the USFS Collaborative Forest Landscape Restoration Program (CFLRP) and through new capacity building programs.[87] Experts observed that the greatest impact on forest restoration happens at the local level and that private/public partnerships have greater resilience to federal government changes. Work to create these collaboratives must keep in the mind the mixed politics of the region and remain bipartisan.

Ongoing efforts to educate the public about wildfires and their ecological role is an essential component of IRC protection. Due to massive wildfires in recent years, there is a shift in public sentiment and a greater understanding of the difference between "good" and "bad" fires. However, experts recommend harnessing "bad" fire events to increase public support for more aggressive forest thinning and prescribed fire.[88] Further, public awareness of fire safety for those who live in the WUI could reduce the number of uncontrollable, high severity wildfires started in dry conditions. Successful efforts include the creation of Firewise Communities, which bring together landowners in the WUI to facilitate the sharing and implementation of best forest restoration practices.[89]

Possible Actions for Expanding Land Protection

While wildfire risk reduction should be the priority in the Sierra area, as mentioned above a significant portion of the Sierra HCA is Gap 4, meaning that there is no known mandate for protection in those areas. As such, some IRC protection efforts could focus on formally protecting those areas.

Investigate Private Ownership and Consider Strategies for Changing GAP Status

More information is needed on the private land contained within the Sierra HCA. Work could be done to identify the largest landowners and work with them to set up forest conservation plans, using carbon credits and other government incentives as motivation. This work could be in coordination with the support of Collaboratives mentioned above.

Conserve More Old Growth Forests

Conserving all old growth forest remaining in the Sierra HCA is a top priority for IRC protection. While only small patches of old growth remain in the HCA, the oldest trees are primarily in GAP 3 or 4 protection spanning private and National Forest land.[90] Prioritizing the most complex forests and then using policies such as 30 by 30 to advocate for and fund their conservation will increase IRC protection.[91]

High Carbon Area:

APPALACHIA

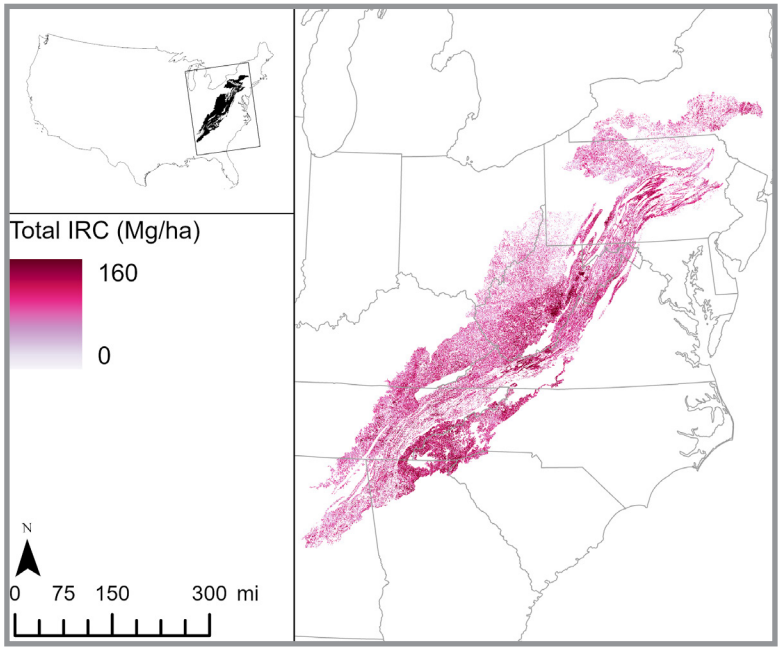


Figure 1: Total IRC in the Appalachia HCA.

HCA GEOGRAPHIC AND CULTURAL CONTEXT

The Appalachian HCA follows the spine of the Appalachian Mountain range, spanning from Alabama to New York. This land is the ancestral and present-day land of over 15 Indigenous groups including the S'atsoyaha (Yuchi), Cherokee, Totelo, Moneton, Mohican, and Abenaki.[92]

Forty-two percent of the population of the Appalachia HCA lives in rural areas and socioeconomic performance of the region lags compared to the rest of the country. Historical industries such as farming, manufacturing, and coal, gas, and other mining, currently only make up a combined 13.4% of total employment in the region. The region's most common jobs are now in professional and technical services, health and social services, and retail trade.[93]

Politically, this HCA leans Republican with 95.2% (400 out of 420) counties in the region voting Republican for the 2020 presidential election.[94] The region's median household income is $53,546, which falls far below the national average and ties closely to the regional poverty rate of 14.7%.[95] Because of the depressed economy of the region, spending on conservation and land protection is likely not an immediate priority, therefore, determining financial benefits from protecting IRC will be key. However, tourism to the area – especially nature-based recreation – makes up a significant portion of economic growth and is generally concentrated along the Appalachian and Smoky mountains, including Shenandoah National Park and Great Smoky Mountains National Park – the nation's most visited national park.[96] Given the increasing value of nature-based tourism in the region, there is the potential to promote IRC conservation alongside tourism and other conservation co-benefits to improve local economies.

IRRECOVERABLE CARBON OVERVIEW

Ecological Characteristics

The majority of the IRC in the region is held in deciduous, temperate forest ecosystems (82.3%). The other common ecosystem is grasslands (17.6%) – primarily temperate with limited subtropical grasslands as well. The nature of the ecosystems results in 99.97% of the IRC being held in biomass with the remaining amount held in soil. This HCA holds 1425 megatonnes of IRC, making it the sixth densest HCA of the 10 across the nation.

IRC Co-Benefits

Ecosystem services provided by the forest ecosystems of the HCA include water filtration, forest products industries, outdoor recreation, tourism, and fish and wildlife conservation, in addition to carbon storage.[97]

Ownership and Management

The majority of the land in the Appalachia HCA – approximately 84% – is privately owned. Private landowners include families

and individuals as well as corporate owners from industries such as timber, agriculture, and coal mining. The region's legacy of absentee corporate ownership is still evident in much of Appalachia, but in recent decades new owners - particularly timber investment management organizations (TIMOs) and real estate investment trusts (REITs) have acquired large parcels of land. Smaller plots held by families and individuals are scattered throughout the region.

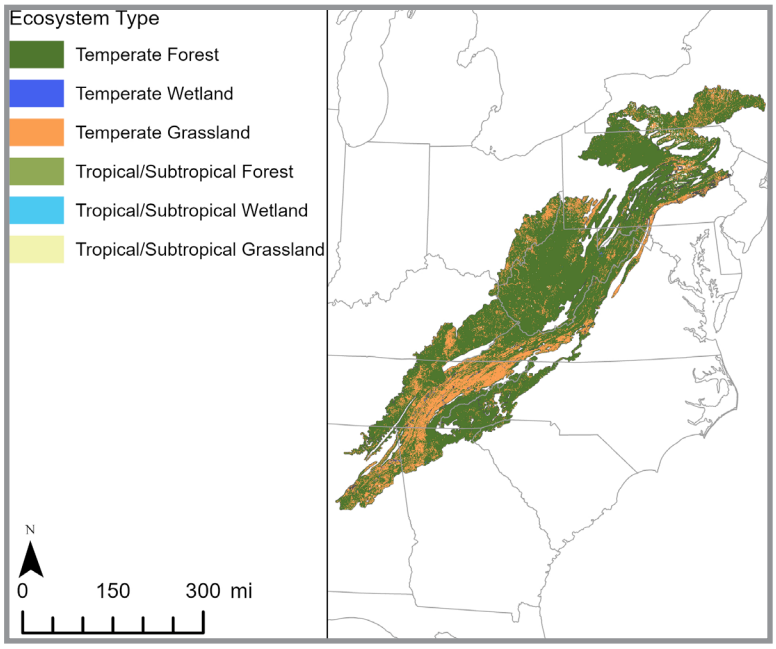
A smaller portion – approximately 7.1% – is federally owned. States in the region own a significant amount of land, though it is only approximately 7.1% of the total land in the HCA. The two state actors that own the largest share of land in this HCA are the Pennsylvania Bureau of Forestry and the Pennsylvania Game Commission. With so much of the land privately owned and managed, there is no uniform approach to land management and conservation across the HCA. The U.S. Forest Service is the dominant federal land manager (84% of federally owned land). Federal and state lands are managed in accordance with forest and recreation plans that range in detail and prescriptive nature. While federal forest management plans offer some degree of protection against development, many national forests in this HCA – such as Pisgah-Nantahala National Forest in North Carolina and portions of Monongahela National Forest in West Virginia – remain open for logging and road construction.[98]

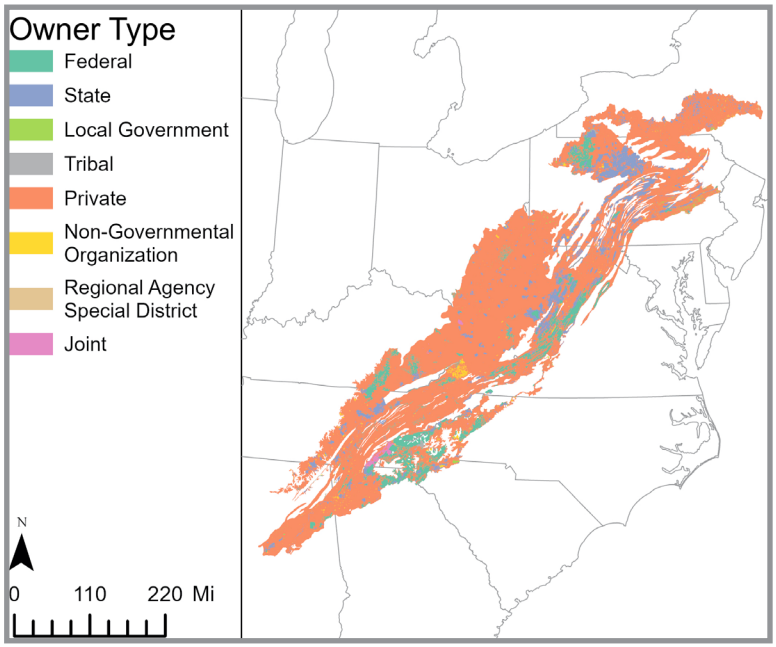
IRC PROTECTION & THREATS

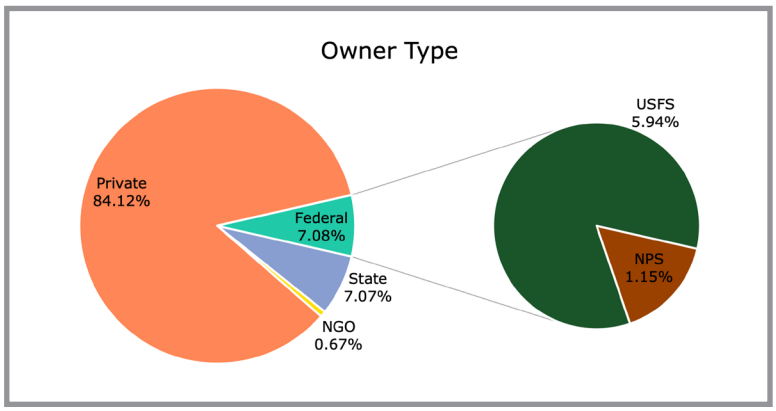
The majority of IRC in this HCA is unprotected. The majority of IRC in the Appalachian HCA is unprotected. Approximately 94% of the IRC in the HCA has either GAP 3 or 4 status, and just 1% is permanently protected from land conversion through GAP 1 status. The most highly protected land in the region falls into the 50 nationally designated wilderness areas within the HCA. One unifying feature across the region is the Appalachian National Scenic Trail. The trail corridor protects over 250,000 acres running along the spine of the Appalachian Mountains.[99] However, this protection includes private land crossing and conservation easements, and while it creates a connected corridor, is a small piece of the patchwork of land protections in the HCA. Given this, organizations such as the Appalachian Trail Conservancy are focused on maintaining and improving connectivity of lands for stewardship, biodiversity protection, and climate resilience.[100]

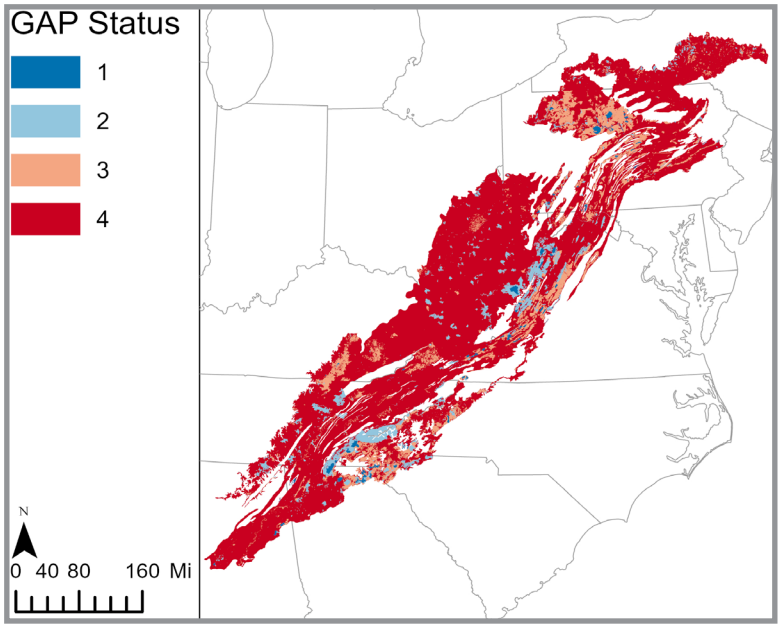
The Appalachian region faces several threats to forest ecosystems and carbon storage, including

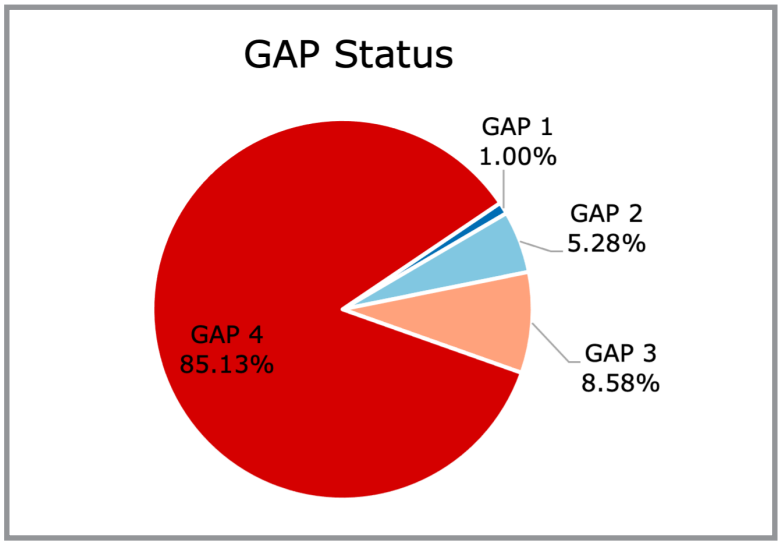
Top - Figure 2: Ecosystem of IRC in Appalachia; **Middle - Figure 3:** Owner type of IRC in Appalachia; **Bottom - Figure 4:** Owner of IRC with federal ownership split into agencies.











Top - Figure 5: GAP Status of IRC in Appalachia; **Bottom - Figure 6:** Breakdown of GAP Status of IRC in Appalachia.

land conversion, population growth, and climate change. Given that the majority of land falls under private ownership with limited protection, major industries, including logging, coal mining, and agriculture, threaten the release of additional carbon stores. Unsustainable forestry practices such as high grading - in which only the healthiest trees are selected for harvest - release IRC while harming forest health.[101] Variations in ownership type, where public lands are commonly broken up and/or are surrounded by private lands, ultimately alter ecosystem conditions. Additionally, climate change contributes to the spread of disease and non-native, harmful species threatening the livelihood of forest ecosystems and native species within the region.[102]

PATHS TO INCREASED PROTECTION

Wilderness designations are viewed as the most durable mechanism to protect important pieces of land.[103] Specifically, there is interest from regional non-profits in growing the number of federal wilderness area designations – a sentiment shared by interviewees. While there is increasing pressure for conservation organizations and federal government entities to acquire and protect more land, capacity issues remain a significant limiting factor. The effort required to build support for wilderness designations overwhelms the resources and staff available to successfully advocate for and manage land. Given the limitations associated with expanding public ownership, approaches that incentivize sustainable management and conservation efforts within private lands must also be considered.

However, even for less durable protections (i.e, conservation easements, state protections, etc.), some small organizations in the region currently lack the capacity to manage or take responsibility for land transfers. Targeting specific smaller organizations and groups with funding and other support could then have an outsized impact on regional IRC protection, providing local-scale resources to build momentum for conservation. For example, as one of the larger non-federal landowners in the HCA, providing resources to Pennsylvania state agencies has the potential to shift management approaches in a significant way and could be a useful opportunity to target an influential stakeholder. Given that many organizations and entities have noted that there are simply not enough resources and staff to manage land under current protection, it will be essential to improve capacity levels by ensuring adequate staff and resources to prevent additional strain on conservation and stewardship organizations – both at the regional and local levels.[104] Specifically, one interviewee suggested that the primary land-owning federal agencies in the Appalachian region increase their capacity to manage additional land, a proposal that might be made possible through increased IRA funding.[105] Both the National Park Service and the U.S. Forest Service have the potential to increase partnerships around management and to recenter carbon-related considerations in such management – as the agencies have in other regions of the country – but are limited by capacity and resources. Leveraging existing federal funding mechanisms – such as the US Land and Water Conservation Fund and the Forest Legacy Program – to protect areas high in IRC offers an additional path to protection.[106, 107]

Another key consideration is the need for local support and involvement to increase IRC protection within this HCA. As one interviewee noted, a significant barrier to getting support for increased land protection is the belief by some residents that these actions will reduce their freedoms. Because such a large proportion of the Appalachia HCA is privately owned, gaining the support of private landowners is essential. As one interviewee

emphasized, “education and support from private landowners is really critical for land protection and the biggest opportunity for protection of carbon in this region is going to be on private lands.”[108] Additionally, multiple interviewees across all HCAs discussed a need for greater inclusion of historically underrepresented populations in decision making processes.[109] Because this region spans so many states and cultural regions, having appropriate, local-based community engagement will be key in garnering support for increasing protections on private lands.

For instance, The Nature Conservancy (TNC) leads a Family Forest Carbon Program (FFCP) in partnership with the American Forest Foundation (AFF) to help 21 million U.S. family forest owners.[110] The program sets out to mitigate forest management activity and carbon market transaction costs, while offering technical and professional assistance to private landowners. TNC and AFF utilize communication tools to offer guidance for small landowners, which is a strategy that can help to gain local support for the increased protection and sustainable management of forest ecosystems. This program serves as one example of the ways in which accessible pathways can be created for private landowners, including those within the family forest industry to enter the carbon market, while simultaneously incentivizing engagement in the protection of IRC.[111]

In addition to acquiring the support of private landowners, there is also a greater need to inform and offer guidance to decision makers regarding which areas are in need of protection and prioritization. To achieve this, there is a need for data availability and consistency to offer a baseline understanding of at-risk areas and barriers to protection, which can be challenging, especially for private land ownership. For example, a regional study by the Appalachian Regional Commission identified a lack of consistent data regarding growth-to-removal ratio, a fundamental measure that identifies areas where unsustainable harvesting is occurring.[112] Once acquired, it is important for the data to be communicated in a way that is understandable to a wide range of stakeholders within and outside of the conservation field. The Family Forest Carbon Program, for example, has developed a new carbon accounting methodology that measures the amount of carbon stored by landowners enrolled in the program.[113] This data, combined with FFCP’s outreach and technical assistance tools, can improve awareness of, and access to, conservation programs and carbon markets among a broader audience.

In approaching further protections in this region, the scale and shape of conservation will be variable and requires flexibility. While IRC protections are key, emphasizing the need to increase ecosystem resilience, expand access to outdoor recreation, and manage invasive species to maintain ecosystem integrity will be important components of efforts to gain support for increased protection across the region. Surveys conducted by USFS have found that family forest owners cite a variety of purposes for owning forest land, the most common being “To enjoy beauty or scenery,” “To protect or improve wildlife habitat,” and “To protect nature or biological diversity.”[114] Highlighting these environmental and economic co-benefits from conservation provides a vital opportunity to generate public support for protecting IRC.

Shenandoah National Park, VA - Francesca Governali.

High Carbon Area:

NORTHERN MINNESOTA / UPPER PENINSULA

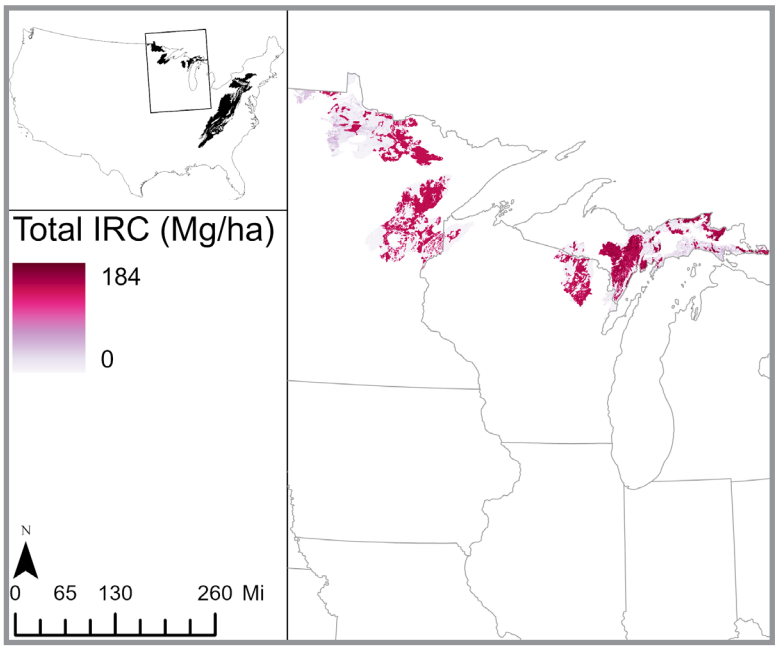


Figure 1: Total IRC in the Northern Minnesota / Upper Peninsula HCA.

HCA GEOGRAPHIC AND CULTURAL CONTEXT

- This HCA encompasses the eastern and central Upper Peninsula of Michigan, northern Minnesota, and northwestern Wisconsin. This land is the ancestral and present-day home of the Sioux (Očhéthi Šakówiŋ), Anishinaabe, Odawa, Mdewakanton, Sisseton, and Michif Piyii (Métis) Indigenous Peoples.[115]
- Politically, it is largely conservative. All Congressional districts within the HCA are currently represented by Republicans who are generally critical of environmental regulations.[116]
- Population decline and a shrinking labor force have produced economic challenges for many regions within the HCA.[117] While these conditions have generated pressure to expand mining operations in some areas, opportunities for new sources of revenue – such as carbon credits – have also proliferated in recent years.[118, 119]

IRRECOVERABLE CARBON OVERVIEW

- The HCA consists of peatlands (39.9% of acreage), temperate forests (32.6%), wetlands (22.9%), and grasslands (4.5%).
- The region holds over 422 megatonnes of carbon; its IRC density ranks fourth highest among the nation's ten HCAs.
- Although 92.5% of the IRC is held in soil, interviews with regional experts indicate that organizations have largely focused their efforts on quantifying forest carbon stocks.
    - Policies targeting forest carbon may also conserve soil carbon, but more data is needed to understand the extent and management of carbon held in peatlands, as well as the specific mechanisms – such as drainage – that release IRC.
- Peatlands within this HCA are diverse, highly productive systems that confer a variety of co-benefits in addition to carbon storage. These ecosystems provide habitat for several threatened and endangered species, improve water quality, maintain stream flows, connect landscapes, and control erosion.
- 68.4% of the HCA's IRC is privately owned; state agencies (21.3%) and federal agencies (9.4%) also account for a significant portion of IRC ownership. The USFS is the primary federal owner (83.5%). Tribal ownership (1.7% of IRC) is located on four reservations.[120]

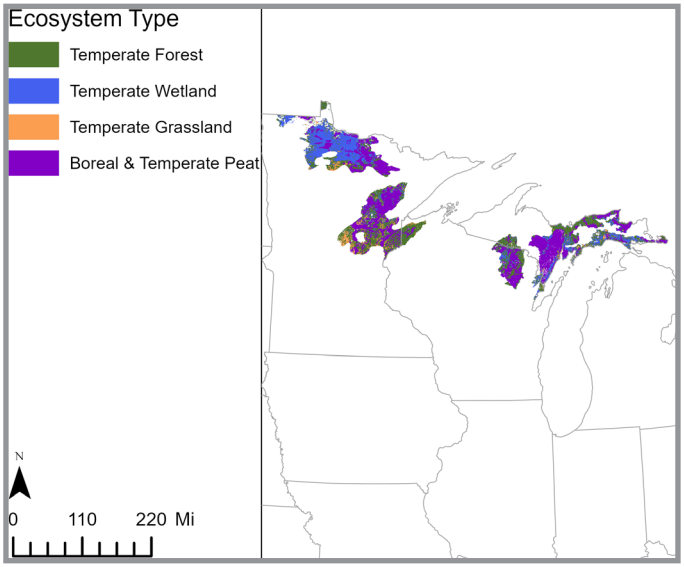


Figure 2: Ecosystem of IRC in Northern Minnesota / the U.P.

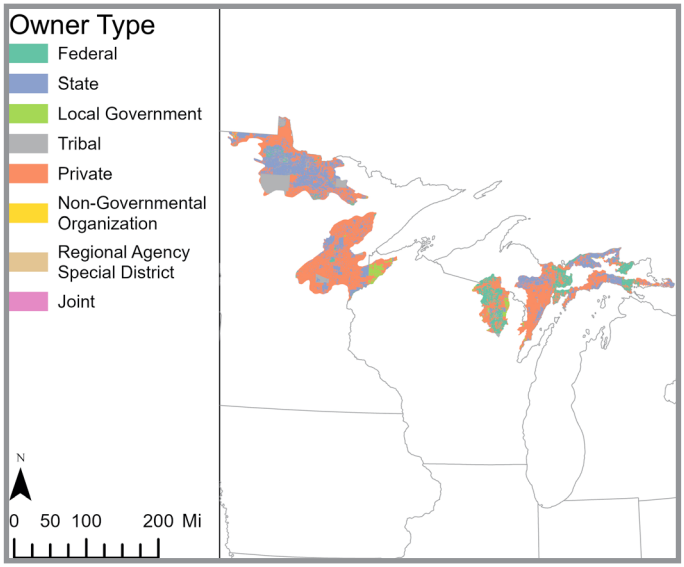


Figure 3: Owner type of IRC in Northern Minnesota / the U.P.

IRC PROTECTION & THREATS

- The majority of land within this HCA is relatively unprotected from development; 70.4% of the total IRC is located on GAP status 4 land (Figure 4).
- The region has been characterized as low-risk for both land-use conversion and climate.[121] However, regulatory gaps remain in the conservation of non-forested wetlands, leaving this ecosystem type vulnerable to drainage and peat mining.[122]
- Most sustainable management initiatives in this HCA target forests rather than wetlands.
  - Although MI DNR is developing a planning model that will integrate forest carbon into future management plans, the agency has not yet quantified non-forested carbon.
  - DNR is reluctant to initiate conservation projects that consider carbon alone, as the agency must "provide not only ecosystem services, but recreation, forest products, et cetera."[123]
- Public-private partnerships and incentive programs have protected portions of the HCA's private lands.
  - The Northern Great Lakes Forest Project, a 2005 partnership between The Nature Conservancy, the State of Michigan, and several private organizations and NGOs, has protected 271,000 acres in MI, including part of the Upper Peninsula.[124]
  - MN's Sustainable Forest Incentive Act offers annual payments to encourage private landowners to keep their wooded areas undeveloped.[125]
- Threats to IRC include climate change; drainage of peatlands for agriculture, road construction, and development; peat mining for soil additives; increased demand for nickel and other minerals; and the expansion of sulfide mining.[126]
  - MN is a national leader in ore production, and growing demand for minerals used to power electric vehicles has generated interest in new mining leases.
  - Peat mining for soil additives poses a potential threat to IRC, particularly in MN, which ranks first in the nation for active peat mining operations. While peat mining is generally prohibited in protected areas or "adjacent non compatible land," state regulations are otherwise lenient.[127]
  - Most current regulations attempt to mitigate the effects of wetland loss rather than proactively protecting these ecosystems, resulting in a net release of IRC. MI, MN, and WI have each developed statewide mitigation programs that intend to achieve "no net loss" of wetlands by establishing new or restored wetland areas in advance of anticipated losses.[128] However, the time and extent of restoration required to recover wetland carbon sequestration functions are not well understood.[129] Thus, current mitigation efforts may not effectively protect IRC.

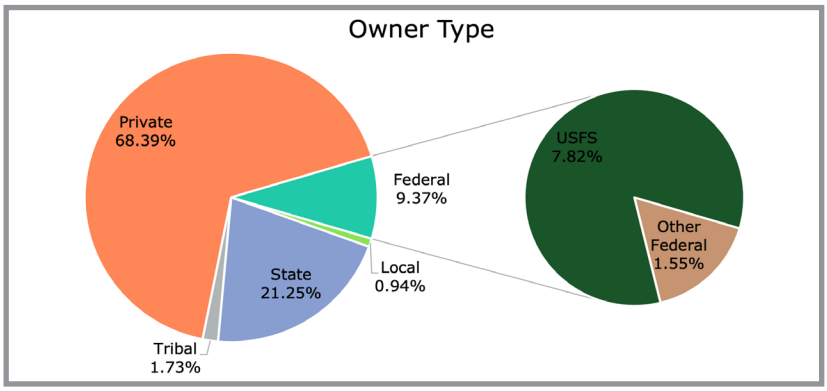
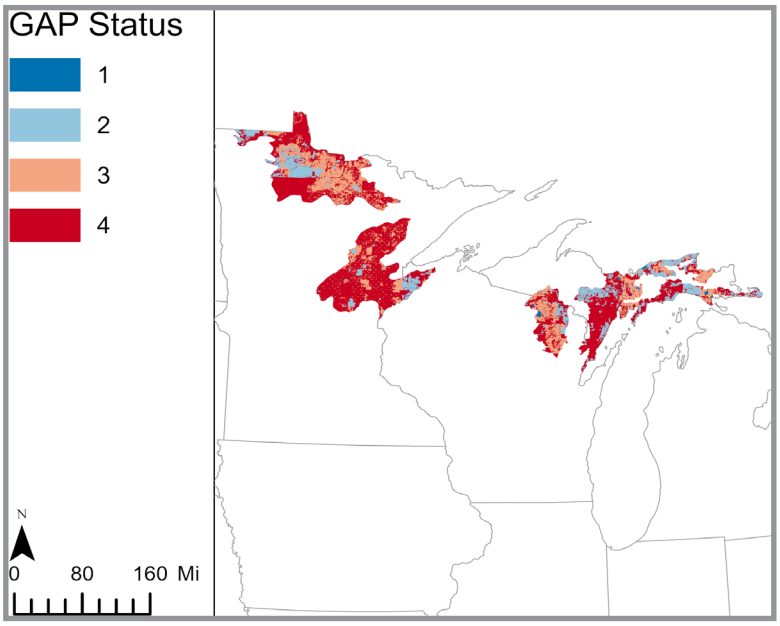
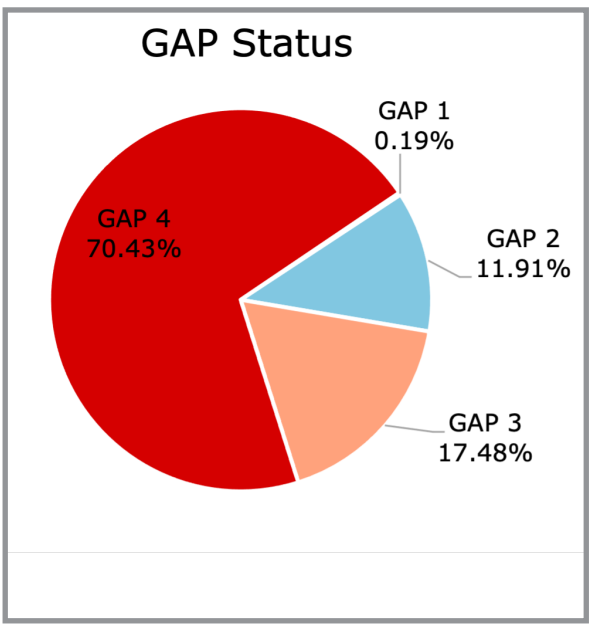


Figure 4: Owner of IRC with federal ownership split into agencies.





Left - Figure 5: GAP Status of IRC in Northern Minnesota / the U.P.**; Right - Figure 6:** Breakdown of GAP Status of IRC in Northern Minnesota / the U.P..

PATHS TO INCREASED PROTECTION

- Financial incentives targeting private landowners present a vital opportunity to expand IRC protections. Conservation easements offer an alternative to less popular regulatory mechanisms: as one interviewee noted, "the solution is not to just make everything part of a state forest or a national park. Politically, there is probably not much will to create a statewide law that governs how property owners can manage their property."[130]
- State agencies are beginning to explore public-private partnerships and voluntary carbon markets as conservation mechanisms; several initiatives, such as MI's Qualified Forest Program, provide financial incentives for private landowners to implement forest management plans.[131]
- Both interview responses and regional political trends indicate that "leading with carbon" is unlikely to serve as an effective communication strategy. Interviewees highlighted the importance of apolitical messaging that links conservation to other priorities, particularly the economy: "For Michigan's business associations, climate issues are "number 11" on their list of top 10 concerns...we need to find a way to create messaging that will help them understand why climate is core to the decisions they're making and their competitiveness. We're trying to figure out how to make this part of the economy."[132]
- Resources targeting private landowners – such as Northern Institute of Applied Climate Science manuals – can help landowners understand how to manage their land for a variety of uses, including carbon storage.[133]
- The extent to which and scale at which peatland restoration increases carbon sequestration is particularly relevant because some "no net loss" strategies on wetlands use restoration to compensate for development elsewhere. Increasing understanding of, and focus on, carbon in these ecosystems will be key.

Boundary Water Canoe Area, courtesy of USFS - Flickr Creative Commons.

High Carbon Area:

ALASKA

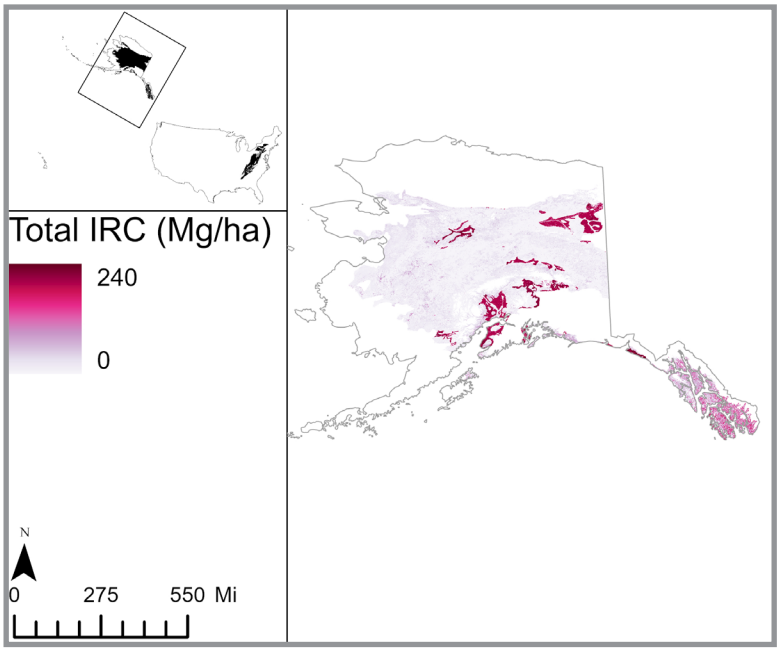


Figure 1: Total IRC in the Alaska HCA.

HCA GEOGRAPHIC AND CULTURAL CONTEXT

- Alaska has two distinct subregions high in IRC: Southeast and Interior Alaska
- Over 100 tribes historically lived across the HCA. The State has now divided tribal management into 12 Native Corporations, each of which contain 15 to 40 tribal groups.[134]
- Alaska has the lowest population density in the country, at 1.6 persons per square mile, meaning there are large tracts of undeveloped land and low land conversion pressures.[135]
- The state leans conservative, with liberal pockets.
  - In 2020, Trump received 52% of the popular vote, Biden 42%.[136] However, there has been somewhat of a recent shift in the political outlook of the state due to a new ranked choice election system, resulting in the election of U.S Rep Mary Peltola (D).[137]
- Currently, the majority of jobs are in the following sectors: government (77,400), transportation, trade, and utilities (64,800), education (private) and health services (50,200), and leisure and hospitality (35,700).[138]

IRRECOVERABLE CARBON OVERVIEW

- The HCA is comprised of boreal forests (42.7%), grasslands (37%), and peatlands (8.7%) of Interior Alaska and the coastal rainforests of South Central and Southeast Alaska (6.6%)
- Alaska contains approximately 1521.69 Mt IRC, about a quarter of IRC in the US, but with a density of 8.4 Mg IRC per acre making it the lowest density HCA.
- Approximately half of the IRC is stored in biomass (48.8%), half in soil (51.2%).
- The majority of Alaskan IRC (49.3%) is federally owned, while 21.4% is in state lands, 23.3% is privately owned, and 5.54% is Alaskan Native managed.
- SOUTHEAST: IRC is USFS managed in the Tongass National Forest (16.6%)
  - Multiple co-benefits, including: timber, recreation, and subsistence hunting and foraging, and watershed conservation. Local people "supplement their year-round diets…with salmon and venison [provided by the Tongass]."[139]
- INTERIOR: IRC managed by the AK Department of Natural Resources (21.3%), Bureau of Land Management (13%), US Fish and Wildlife (16%), National Park Service (3.7%), and Alaska Native Corporations (5.5%).[140]
  - Boreal forests provide climate regulation, e.g. carbon storage capacity to offset melting permafrost and resilience to wildfire.[141] More research is needed on other co-benefits.

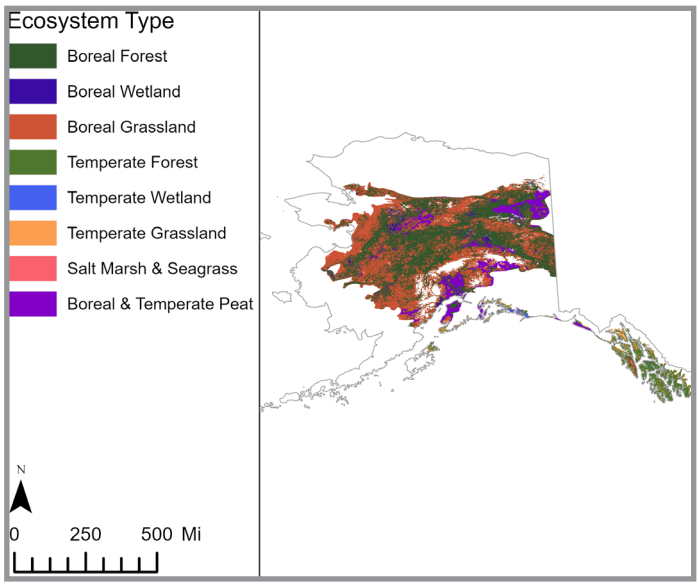


Figure 2: Ecosystem of IRC in Alaska.

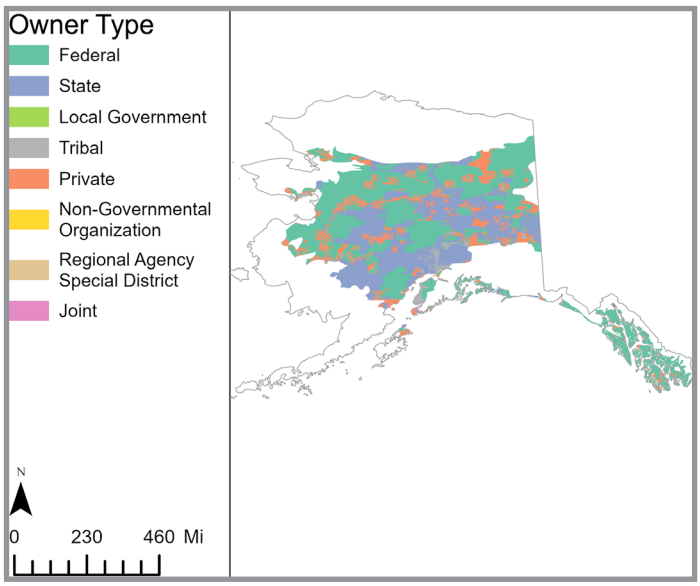


Figure 3: Owner type of IRC in Alaska.

IRC PROTECTION & THREATS

- Nearly 50% of the IRC is GAP 4, with the remaining IRC mostly divided between GAP 1 and 3 (Figure 6).
- The level of protection and nature of the threats is different between the Southeast and Mainland. In general: Carbon protection is not formally incorporated into federal and state agency plans.[142]
- SOUTHEAST: Greatest threat to IRC is land conversion through logging and federal policy change. Wildfire risk is low.[143]
    - Roadless Rule effectively protects areas in the Tongass National Forest, as does local reliance on non-timber forest products and resulting local opposition to large scale-logging. In January of 2023, the Biden administration permanently banned the development of roads and logging in the Tongass.[144] This was a reversal of a Trump era rule exempting the Tongass from the 2001 Roadless Rule. While protected now, the Tongass could be vulnerable again should a new administration reinstate Trump's Tongass exemption.
    - Greatest risk is a pro-timber Administration in the White House overturning the Roadless Rule and increasing extractive logging.[145]
- INTERIOR: Primary threats are land conversion and logging, shifts in forest ecosystems due to climate (e.g., white spruce declines and greater proportion of deciduous trees), minimal wildfire: reduced risk due to the forests' patchy nature and interspersed wetlands.[146]
    - Much of IRC is already protected from land conversion in state and federal land.[147]
    - Low value timber forests mean a lower threat of carbon release due to logging activity.[148]
    - ANC managed forests face greater threat due to extractive logging practice, but tribes have growing interested in less intensive management practices, using carbon credits to fund.[149]
    - A recent USGS study indicated that, even with increased wildfire and permafrost melting, forests will increase carbon storage capacity due to climate shifts.[150]
    - Beyond protection status, the area is so vast that land management agencies have a "miniscule" impact on the carbon flux.[151]

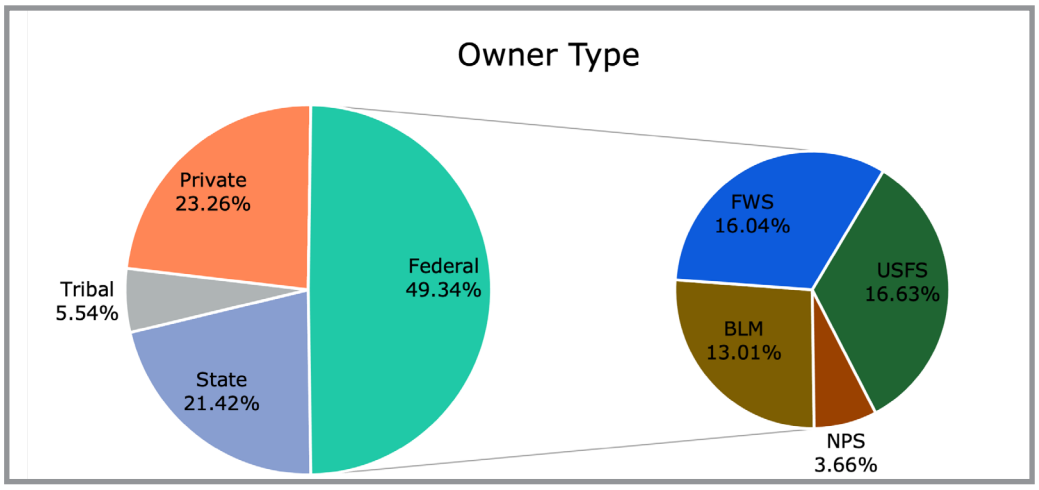
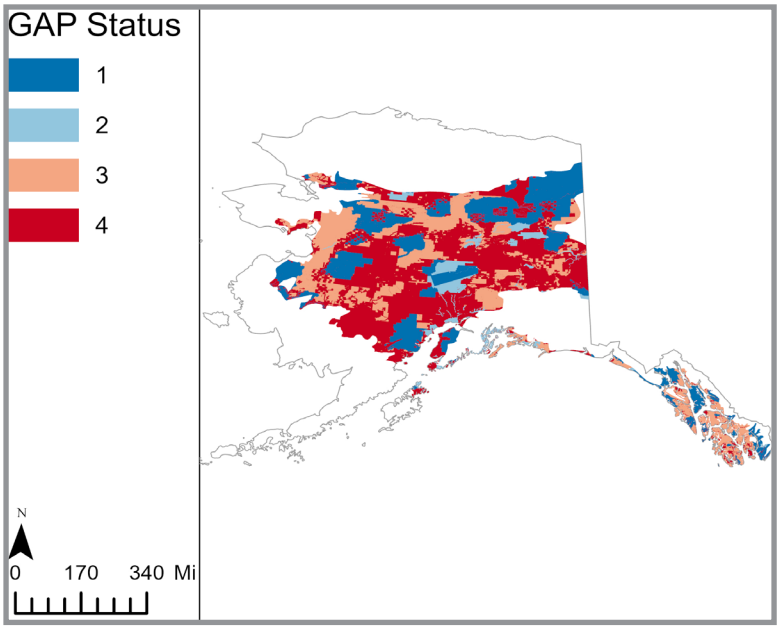
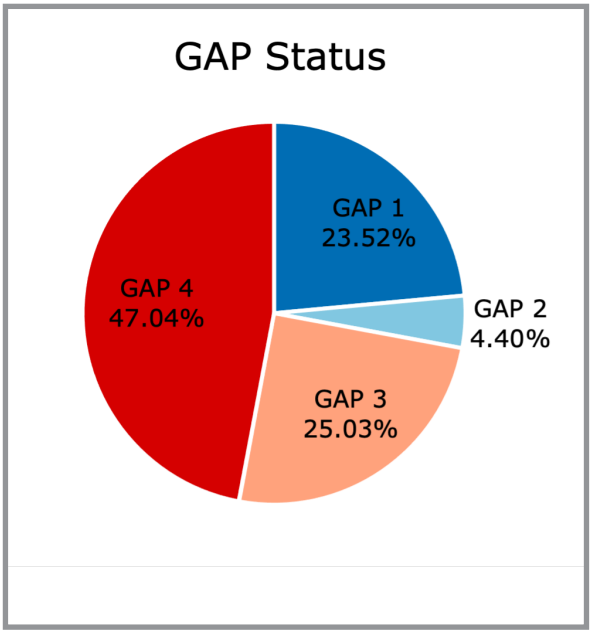


Figure 4: Owner of IRC with federal ownership split into agencies.





Left - Figure 5: GAP Status of IRC in Alaska; **Right - Figure 6:** Breakdown of GAP Status of IRC in Alaska.

PATHS TO INCREASED PROTECTION

Southeast Alaska

- No current action needed to increase IRC protection, instead agencies and activists should work to maintain and deepen stability of current protection.
  - Monitor federal politics and be ready to challenge any future changes to the Roadless Rule.[152]
- Simultaneously, maintain and increase local support for Tongass forest conservation.
  - People need jobs and housing, thus investing in local sustainable development as an alternative to an extraction-based economy, is a critical component of protecting IRC.[153]
- Given the conservative lean of Alaska residents, enhancing and protecting carbon storage is not the most compelling argument, so focus should be placed on economic benefits of conserving IRC rich landscapes.
  - Communication efforts related to Tongass protection should directly tie to local livelihoods, emphasizing the importance of "healthy forests for strong deer populations, healthy salmon streams...and a diversity of species for foraging."[154]

Interior Alaska

- On federal and state lands, no action needed to increase IRC protection, instead maintain protection.
  - Agencies should add carbon storage as a co-benefit / additional reason for land protection.
  - This can be done via several different pathways:
    - Incorporating economic cost-benefit analysis of the value of protecting carbon stores via actions such as restricting development.
    - Studying and quantifying the relationship between IRC and other ecosystem services that currently guide management decisions.
- On ANC lands, work with tribes to create economically and culturally viable pathways to shift away from extractive logging practices
  - Carbon credits are in the infant stage, but have incentivized initial tribal efforts to conserve land and manage forests for carbon storage.[155] Further research is needed.
  - Critical to respect tribal knowledge and to work with tribes to better understand their interests and needs and what other approaches could help them protect IRC.

High Carbon Area:

CAROLINA COAST

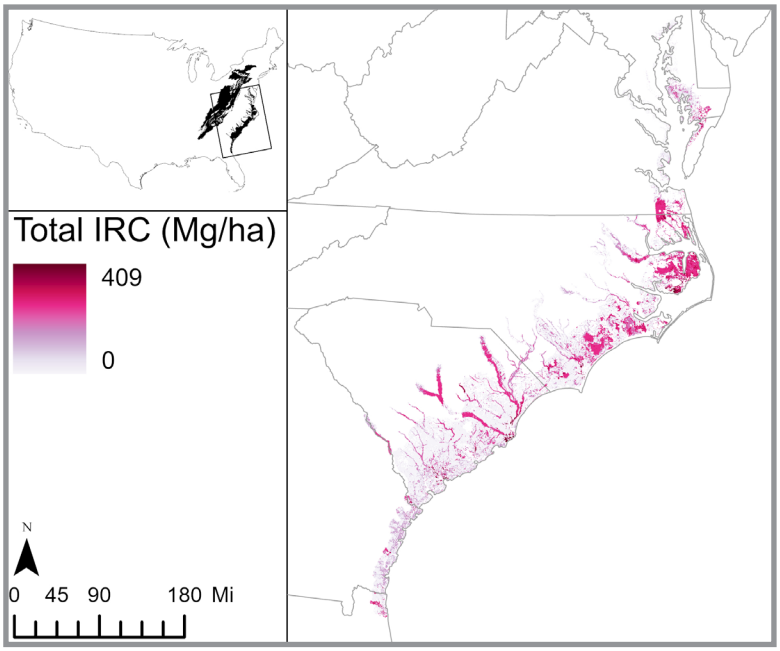


Figure 1: Total IRC in the Carolina Coast HCA.

HCA GEOGRAPHIC AND CULTURAL CONTEXT

- The Carolina Coast HCA is located on the coasts of North and South Carolina with smaller areas along the coasts of Maryland, Virginia, and Georgia.
- Demographics: The area is experiencing population growth and demographic changes, with implications for land conversion.[156]
  - The total population of this HCA is 13,445,554 with an average per-county population of 116,917. Most people in this HCA live in urban areas, although rural living is commonplace: in North Carolina, for example, one in three residents lives in a rural area.[157]
  - North Carolina experienced the third-highest population growth of any U.S. state in 2022, and the state's overall population of 10.55 million is approximately double that of South Carolina.[158]
  - While population centers are concentrated in both inland and coastal areas, the boom of development on the coasts of North and South Carolina has resulted in conversion of farmland and wetland for housing as well as affected the overall health of the coasts vis a vis wetland damage and structural changes to the coast (seawalls). This has a direct effect on releasing IRC, which is primarily held in below-ground soils in wetlands, peatlands, and salt marshes along the coast.
- Politics: While demographic changes have shifted the political landscape of the region, the region leans conservative, which has implications for carbon conservation messaging or environmental communication—especially if communication about conservation appears to come from out-of-state or very progressive organizations.[159]
- Tourism: The HCA has many vacation destinations, including the Outer Banks of North Carolina, Charleston, SC and Savannah, GA.
  - Tourism is South Carolina's largest industry, pulling in over $15 billion in annual revenue.[160] North Carolina pulled in $28.9 billion in tourism dollars in 2021 and was the fifth most-visited destination for domestic tourism.[161] 159.2 million visitors spent a total of $34.4 billion in Georgia in 2021.[162]

IRRECOVERABLE CARBON OVERVIEW

- The HCA is composed of deciduous temperate forests (49.2%), wetlands (24.3%), peatlands (14.6%), and salt marshes (8.6%).
- Total of 355 Mt IRC are concentrated in the HCA, with an average density of 44.5 Mg IRC per acre, making it the 6th most dense out of the 10 HCAs.
- 92.43% the IRC is in soils (including wetlands, salt marshes, and peatlands), with the remaining 7.6% in biomass (trees and other vegetation). This breakdown is typical in coastal HCAs; the IRC in Western HCAs, for comparison, is primarily found in trees.
- Co-benefits of protecting IRC areas include: enhanced water quality, flood protection, urban heat island mitigation, recreation, biodiversity, and local fisheries support.
  - Local people tourists, and municipal employees value clarity and "purity" of near-shore ocean water, salt marshes, and

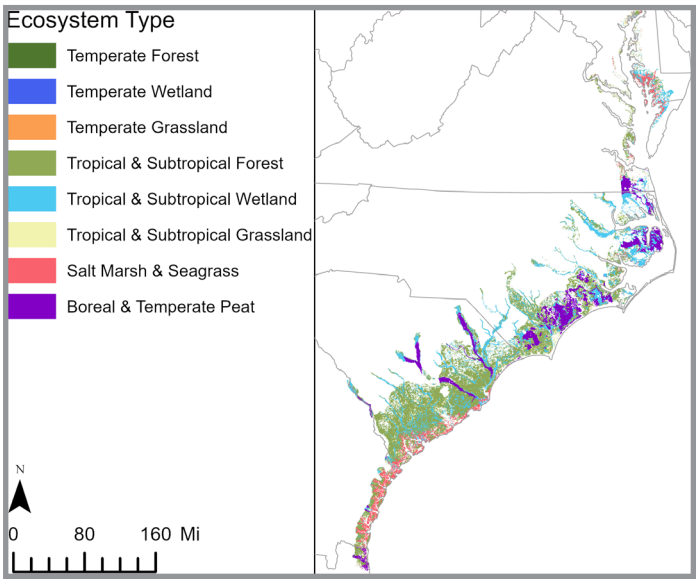


Figure 2: Ecosystem of IRC in the Carolina Coast HCA.

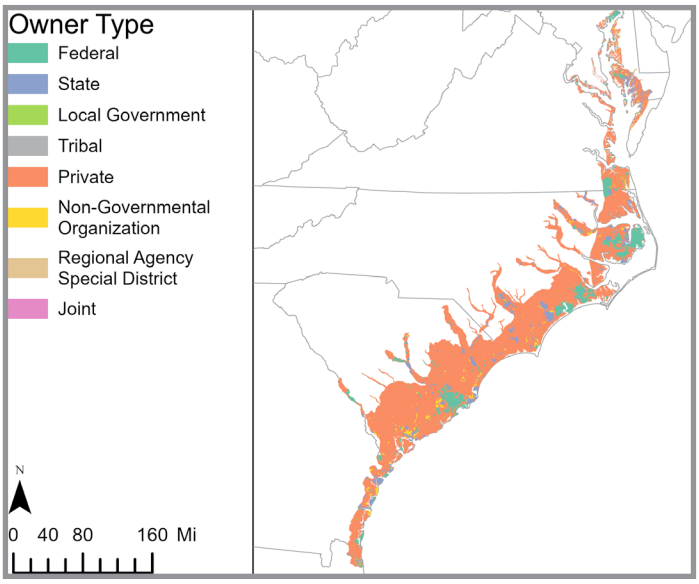


Figure 3: Owner type of IRC in the Carolina Coast HCA.

wetlands for swimming, fishing, duck hunting, and recreation.

- Clean drinking water concerns motivate protection, especially with increased agricultural runoff and North Carolina's rural plumbing and drinking water access challenges.

- Oysters grown along the North Carolina coast are an important food staple as well as a cultural touchpoint for many, and there is strong interest in growing the industry. Oyster farms and beds are often created as part of "living shorelines" instead of typical sea walls, which are harmful to biodiversity and coastal integrity. These "living seawalls" help keep salt marshes and wetlands intact, which helps keep IRC sequestered.
- 75.4% of the IRC is privately owned, 13.0% is federal, 8.4% is state, and 2.5% is private conservation land.
  - The U.S. Fish and Wildlife Service manages the largest amount of IRC in this HCA behind private landowners, followed by the USDA Forest Service, the Public Service Authority, the U.S. Navy, then the state natural resources departments in South Carolina, North Carolina, Maryland, and Georgia.

IRC PROTECTION & THREATS

- 78.5% of IRC is USGS Gap 4, meaning there are no known protections against land conversion (development or extraction). The remaining is a mixture of USGS GAP Status 2 and 3 (18.9%), with a limited amount of very protected GAP 1 land (2.6%) (Figure 6).
- Threats are high due to the large amount of private IRC in the HCA, and include land-use change via sale to developers, private conversion of land, sale of timber, and wetland and salt marsh drainage.
- Salt marshes and tidal wetlands are particularly vulnerable to damage and degradation. According to a 2009 study, the lower 48 U.S. states lose 80,000 acres of coastal wetlands annually. Given that the majority of the IRC in this HCA is held in coastal wetlands, salt marshes, and peatlands, protecting these coastal wetlands from conversion or loss will also help keep IRC intact.[163]
- Other concerns are commercial development, excessive flooding due to storms, coastal erosion, and sea-level rise, all of which release IRC—however, global concerns such as coastal storm surges and sea-level rise are much more difficult to address with localized action than erosion or development are.

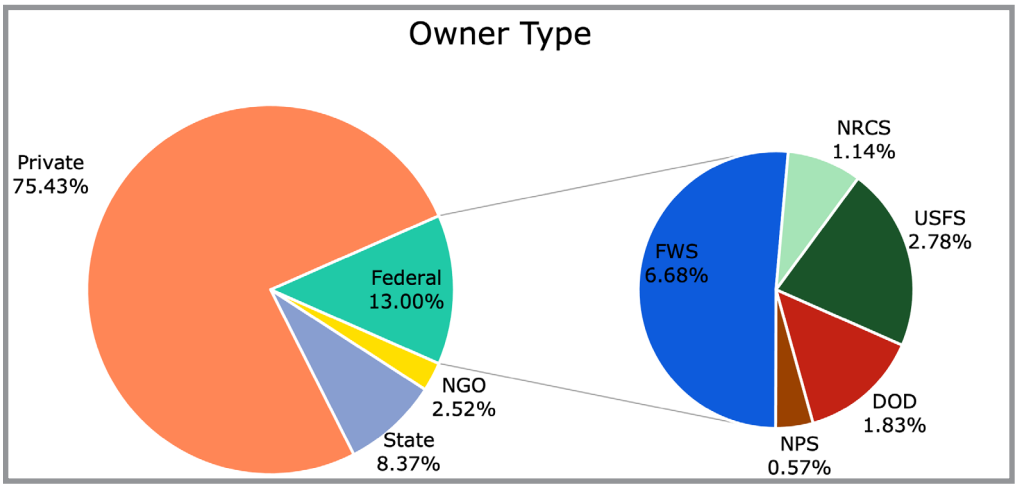
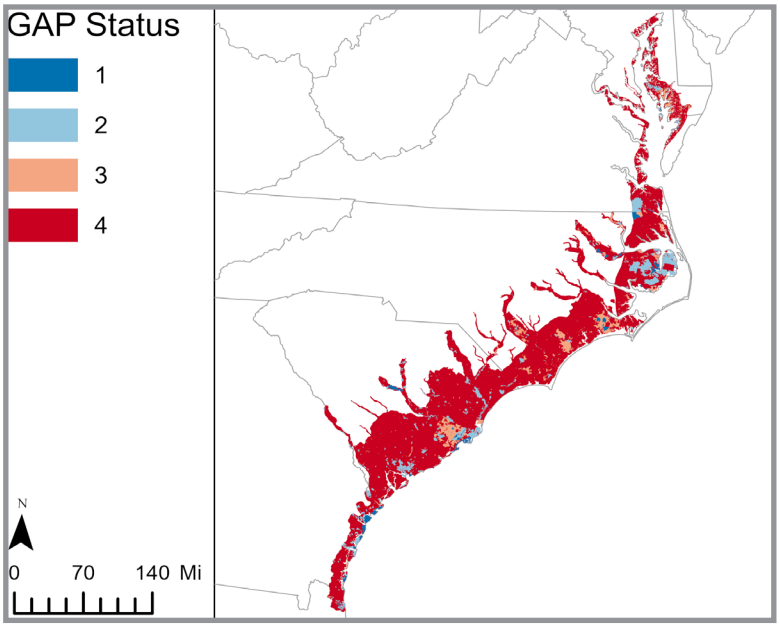
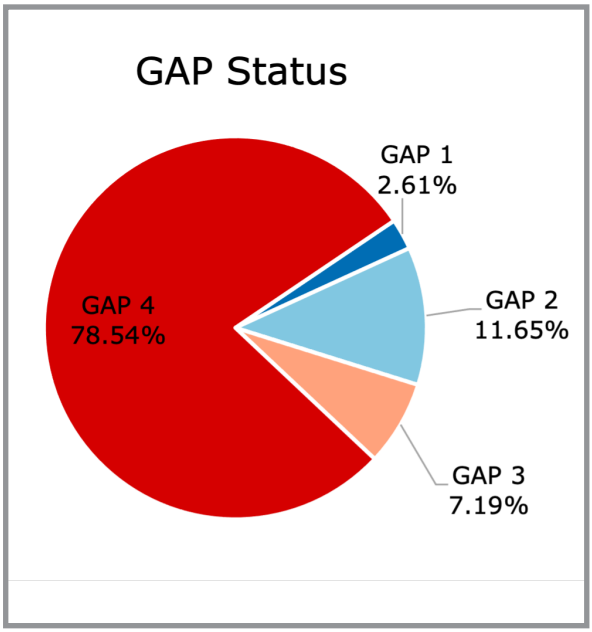


Figure 4: Owner of IRC with federal ownership split into agencies.





Left - Figure 5: GAP Status of IRC in the Carolina Coast HCA; **Right - Figure 6:** Breakdown of GAP Status of IRC in the Carolina Coast HCA.

- Few, if any, protections against development exist in the HCA due to housing concerns and a booming population.
- Several political and policy mechanisms prevent or slow widespread IRC-protecting behaviors:
  - North Carolina's General Assembly has passed laws that prevent local regulations—notably, stormwater programs—from exceeding the scope or strictness of existing state or federal programs. This is a major setback: nature-based stormwater infrastructure strategies would protect high-IRC areas and also result in numerous co-benefits, like reduced flooding and cleaner watersheds.[164]
- According to numerous land conservation professional interviewees in this HCA, efforts to conserve and restore salt marshes and wetlands are most successful when appealing to desires to conserve co-benefits—such as duck hunting, water quality, shoreline recreation, and the health of the oyster industry.
  - Oysters' ability to clean and filter water is a key intersection point between water concerns, the growing oyster industry, and protection against flooding or erosion due to climate change.[165]
- Current protections against development: North Carolina's Coastal Area Management Act regulates—and, in some cases, limits—development in coastal areas.[166] Through NOAA's Coastal and Estuarine Land Conservation Program (CELCP), which provides funds to state and local governments to "purchase threatened coastal and estuarine lands or obtain conservation easements," states within the HCA have implemented 18 acquisition projects permanently protecting over 30,000 acres of land.[167, 168]

PATHS TO INCREASED PROTECTION

- Since the majority of IRC is held in private lands, the best paths to increase IRC protection rest with appeals to private landowners and corporations.
- Intrinsic appeals and barriers: There is no single psychological explanation for, nor academic rationale behind, what works to motivate private and corporate stakeholders.
  - Concerns related to the local climate—such as recent hurricane damage, water quality, and flooding concerns—as well as overall "belief" in climate change as fact affect motivations to conserve land.[169]
  - Distrust in the federal government, which is primarily related to political leanings and historic strength of local governments in the area, can also cause resistance to conservation efforts like those from federal agencies like NOAA.[170]
  - However, the presence and persistence of local conservation professionals can increase the likelihood of private and stakeholder support in this area.
  - Landowners have deeply rooted connection to place and pride in generational ownership. Appealing to these legacy sentiments decreases the likelihood that a landowner will sell a parcel to a developer.[171]

Nags Head, NC, LareDawg - Flickr Creative Commons.

- Regional interviewees highlighted several communication strategies that advocates of IRC protection could use:
  - Show up, over and over, at the local level to earn trust.
  - Make use of landowners' historic connection to the land and invoke legacy—the importance of their own children being able to enjoy the land—as a key lever that has worked in previous land trust deals
  - Use carefully chosen language to engage conservative citizens; do not mention "greenhouse gasses" or "climate change." Despite the public's overwhelming acceptance of climate change as fact, these keywords immediately politicize the issue, resulting in total shut-down from an engagement perspective. According to one interviewee from North Carolina, "If it wasn't political, they'd support it! But [the messages] are seen to come from progressive groups."[172]
  - To overcome political barriers, use trusted messengers to convey information and ensure positioning is not one-sided.
- Possible policy strategies:
  - Leverage the billions of dollars for coastal resilience and conservation projects in the Bipartisan Infrastructure Law and the Inflation Reduction Act. Because federal efforts are generally mistrusted, especially by private landowners, it is recommended that federal agencies such as NOAA or the U.S. Fish and Wildlife Service collaborate with local organizations and trusts to carry out federal funding implementation for coastal areas.
  - Create direct payments and subsidies offered to private landowners in exchange for keeping land intact, though it remains unclear whether a permanent tax structure is politically feasible in terms of regional support.
  - Create state and local zoning that prioritizes urban density and reduces low density sprawl in high-carbon coastal areas.
  - Use coastal resilience co-benefits such as tourism, oyster farming, storm, flooding, and sea-level rise protection to motivate state governments to prioritize management plans, subsidies, and policies that support carbon-friendly projects.
  - Work towards undoing North Carolina's state restrictions on local stormwater and coastal protection regulations.

High Carbon Area:

SOUTH FLORIDA

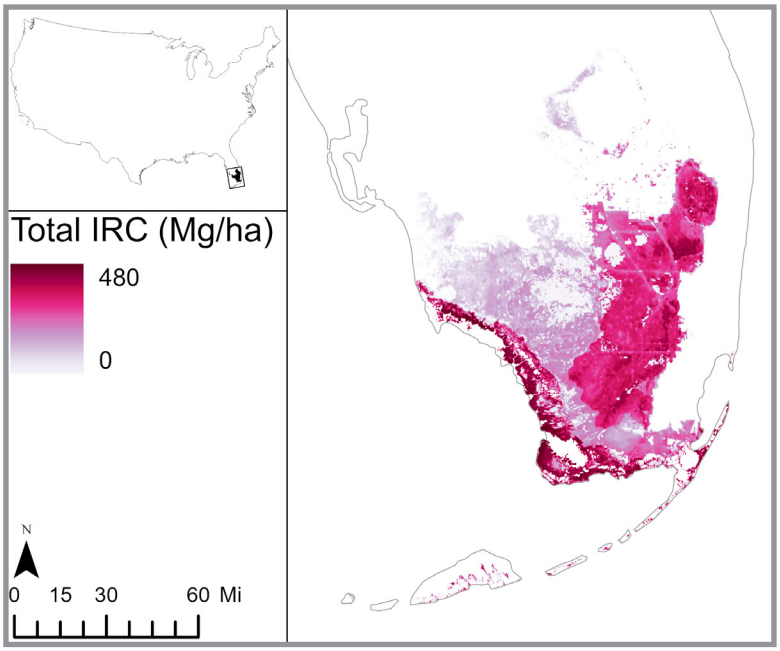


Figure 1: Total IRC in the South Florida HCA.

HCA GEOGRAPHIC AND CULTURAL CONTEXT

- Southern Florida Coastal Plain – Gulf to the Atlantic Coast and Florida Keys.
- The total population of the region is 9.34 million, with 76.5% of the population living on the coast, increasing development in coastal areas where high IRC is located.[173]
- Florida is known for its diversity of natural environments as well as its tourism and agriculture industries.
- State-wide politics favors conservative with conservation remaining a priority within the current administration.[174]
  - Majority of white, college-educated, and Republican residents towards the Gulf Coast of the HCA.
  - Increase in Democratic residents, including BIPOC communities, including immigrants from Cuba, Columbia, and Mexico.[175]

IRRECOVERABLE CARBON OVERVIEW

- IRC is concentrated in mangrove forests (11.6%) and coastal and freshwater wetlands (34.6%).
  - Inland ecosystems include forests, wetlands, and marshes, including the Everglades National Park.
- The region holds over 317 megatonnes of carbon; its IRC density is the highest among the nation's ten HCAs.
- Most of the IRC is stored in the soil (99.2%).
- Florida's coastlines provide multiple co-benefits, including ecotourism, recreation, fishing, and protection. Undeveloped coasts remain relatively high in Blue Carbon.[176]
  - Mangroves and coastal wetlands offer protection from natural destruction, including hurricanes and flooding, and drinking water for one-third of Floridians.[177]
  - Both coastal and inland ecosystems containing IRC are crucial wildlife habitats and refuges for a large variety of species.
- 44% of IRC is federally owned and managed while 22.2% is privately owned and managed; 27.8% is owned and managed by the state and 0.9% on tribal land.
- The US National Park Service manages 92% of the federally owned IRC.

IRC PROTECTION & THREATS

- 34.3% of IRC has GAP 1 protection, 3.7% GAP 2, 37.4% GAP 3, and 24.6% GAP 4, with the GAP 1 area falling primarily in the Everglades National Park.
- Primary threats include: climate change, extreme weather patterns, and natural disasters
  - Coastlines face sea level rise and shoreline erosion; Natural disasters are decimating large areas that store IRC.
- Additional threats include: tourism and agricultural development, private land acquisition
- Legislation (incl. Coastal Barrier Resources Act, Mangrove Protection Act, and Section 404 of the Clean Water Act) have helped boost IRC protection.[178]

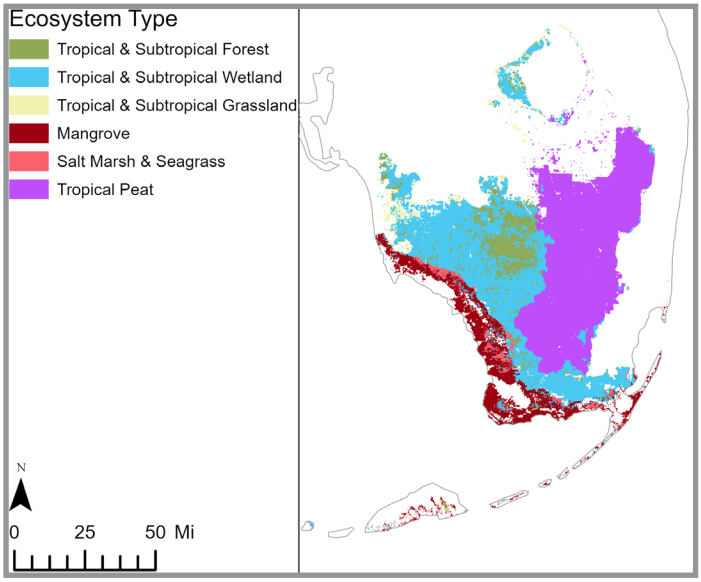


Figure 2: Ecosystem of IRC in South Florida.

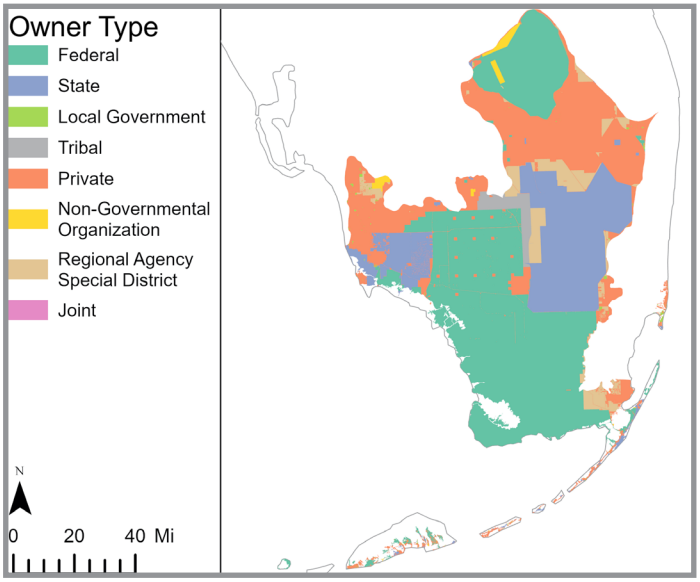


Figure 3: Owner type of IRC in South Florida.

- Everglades Forever Act has helped restore and protect the everglades, an area that contains a significant amount of IRC (at least 46% of IRC) in S. Florida.[179]

PATHS TO INCREASED IRC PROTECTION

- Keep in mind: Develop solutions that prioritize IRC protection while addressing the needs of Florida's residents and visitors.[180]
- In S. Florida, the state government and general public lean conservative. Both sides of the political spectrum place value in Florida's natural environments. However, the way in which land should be protected and managed differs between political parties.
  - The result: Challenges to pass related state-wide laws, including securing sufficient funding to implement and manage policies.
  - Current legislation, including the Farm Bill, can be used as a tool to further protect inland forest systems containing IRC (already at ~30%).[181]
- How can ecosystems high in carbon that undergo natural destruction (e.g., hurricanes, flooding) be protected from threat of land acquisition?
  - One solution: FEMA can purchase, restore, and protect damaged land. However, the agency faces capacity and resource barriers to manage land under current protection and acquire additional land. Also, much of this damaged land is already privately owned or threatened by private land acquisition, which are additional hurdles for IRC protection.
  - [182]To help improve IRC protection and management practices, there is a greater need to advocate for increased funding to bolster staff and resources for state and federal agencies, including FEMA. Collaboration between stakeholders, including government agencies, non-profit organizations, and the public can promote knowledge and resource sharing as well.[183, 184]
- Non-regulatory action: engage with and create incentives for private landowners (farmers, business-owners, etc.).
  - Emerging awareness – and growing market – of carbon storage offers a unique opportunity to satisfy multiple co-benefits.[185]

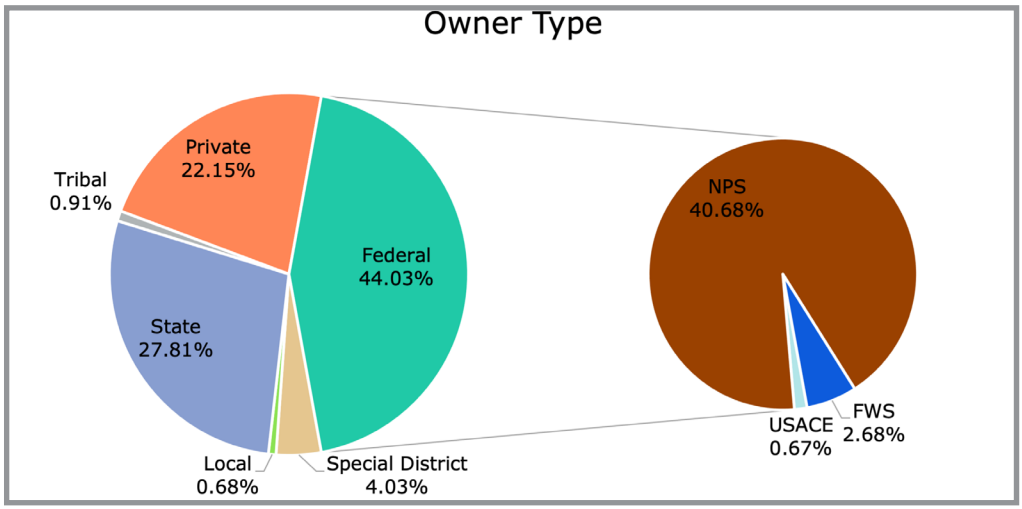
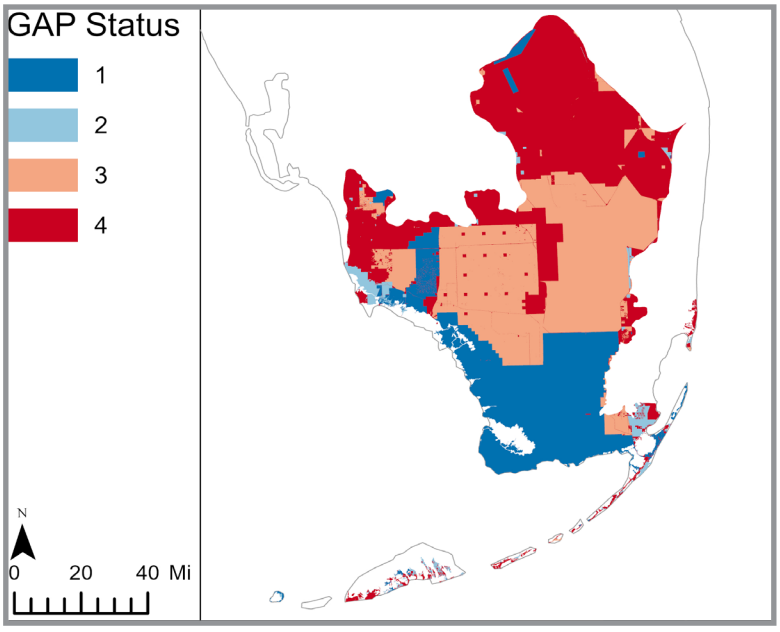
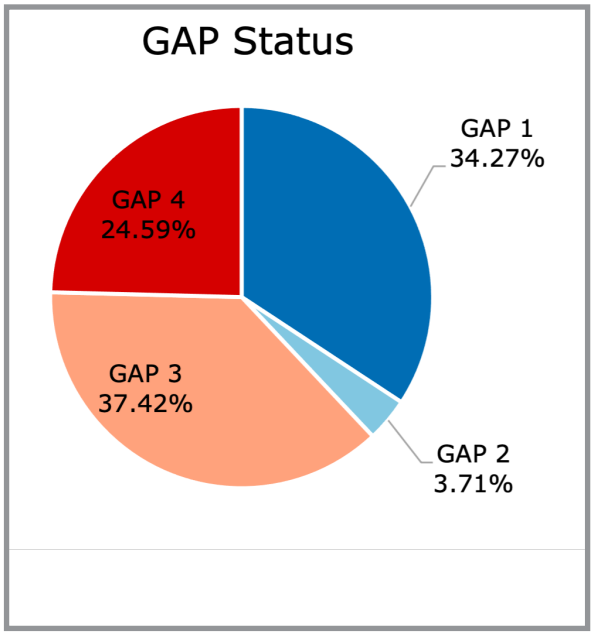


Figure 4: Owner of IRC with federal ownership split into agencies.





Left - Figure 5: GAP Status of IRC in South Florida; **Right - Figure 6:** Breakdown of GAP Status of IRC in South Florida.

- Carbon markets and mitigation banks are avenues for carbon conservation in the greater Gulf Coast region. At the same time, future solutions need to be profitable for private landowners – and feasible for local and state governments.[186]
- Example: A part of EPA's National Estuary Program, Restore America's Estuaries partnered with the consulting firm Environmental Science Associates to publish the Tampa Bay Blue Carbon Assessment, which highlights the potential of a carbon market in relation to restoring and protecting estuaries (high in IRC).[187, 188]

- Education and Advocacy across Sectors:
  - Educate high-level officials as well as the general public – focusing on communities across political, cultural, economic spectra.
  - When engaging with communities, elevate co-benefits, including other ecosystem services, community economy, public health, and quality of life rather than focusing solely on the IRC concept.[189]
    - As part of the Everglades Foundation focus on science, advocacy, and education, their Everglades Literacy Program sets out to educate and empower Florida's next generation through K-12 and teacher programming in communities across the state.[190]
  - When connecting with different voter groups, understand their "social circles" in terms of who they interact with, who is in their sphere of influence, and how they source their information – work with someone that they can trust, who can reach out to them rather than a specific political party or environmental group. Especially in Spanish-speaking communities, it is key to have a sensitivity towards differences in communication platforms and methods.[191]
    - Carbon can be used as an argument, but not with conservative voters, especially older generations.[192]
  - Voices of BIPOC communities need to be elevated to create effective and equitable change. As the cultural and political spectrum continues to evolve in South Florida, BIPOC and Spanish-speaking voters need to be better supported to lead the formation of environmental coalitions and initiatives.[193]

High Carbon Area:

GULF COAST

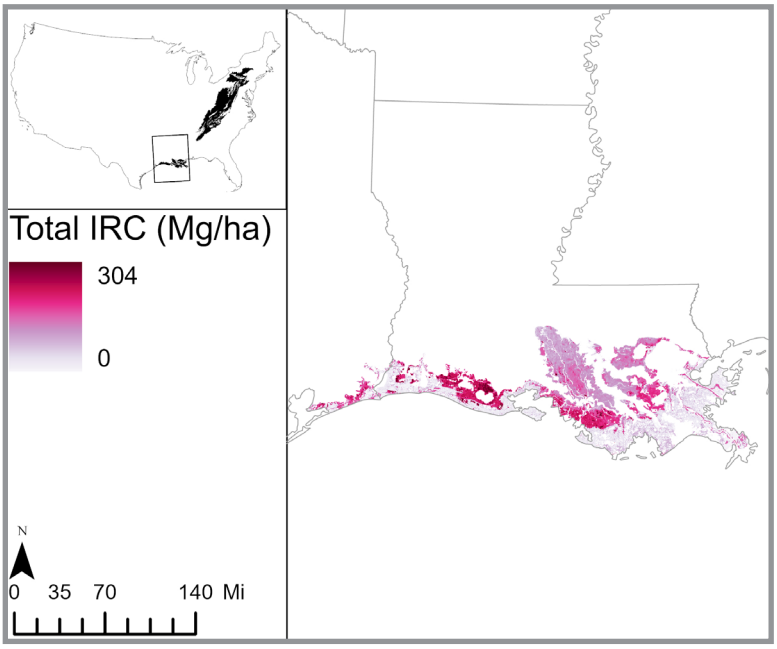


Figure 1: Total IRC in the Gulf Coast HCA.

HCA GEOGRAPHIC AND CULTURAL CONTEXT

- Coast of Southern Louisiana, with small amounts of IRC northeast of Houston.
- Conservative population: Trump won decisively in 2020.[194]
- Industries with impact on IRC ecosystems include: Petrochemical and oil, tourism, commercial development, and fishing.

IRRECOVERABLE CARBON OVERVIEW

- The HCA is comprised of wetlands (53.6%), salt marshes (36.2%), and peatlands (5.9%)
- Total of 311 Mt IRC, Density of 44.4 Mg IRC/acre, making it the second most dense HCA due to the high concentrations of carbon stored in wetlands and salt marshes relative to forests.
- 95.5% of the IRC is in soils, with the remaining 4.5% in biomass.
    - Coastal carbon is frequently termed "blue carbon."[195]
- 89% of the IRC is privately owned, 6.4% is state-owned, and 4.3% is federally owned.
- Co-benefits of protecting IRC include: enhanced water quality, flood protection, tourism, fishing.
    - In Texas, research has shown that good water quality is a cross-cutting value across political boundaries. "Water is as valuable as oil for the people of Texas," said one regional expert.[196]

IRC PROTECTION & THREATS

- The majority of IRC is unprotected with over 90% of the IRC falling under GAP 4 status (Figure 6).
- Threats to IRC are high due to the large amount of private IRC in the HCA, and include land-use change via sale to developers, private conversion of land, and wetland and salt marsh drainage
- Salt marshes and tidal wetlands are particularly vulnerable to damage and degradation, a risk that is exacerbated by the increased risk of large hurricanes caused by climate change. According to a 2009 study, the lower 48 U.S. states lose 80,000 acres of coastal wetlands annually.[197] Louisiana loses a football field of marsh every two hours.[198]
- According to regional conservation experts, IRC-related protection successes, opportunities, and challenges are:[199]
    - Section 404 of the Clean Water Act protects marshes fairly well via mitigation policy, though associated regulation is unpopular with local communities.
    - The National Resources Conservation Service Wetlands Reserve Program in the Mississippi Delta protected approximately 750,000 acres via permanent easements.[200]
    - The Army Corps of Engineers is working on restoring river channels, which they previously significantly altered, to increase marsh protection.
    - Many gulf states have successful coastal planning initiatives, particularly in Texas, including the Texas Coastal Resiliency Master Plan. There's also the CPRA in Louisiana (Coastal Protection and Restoration Authority).

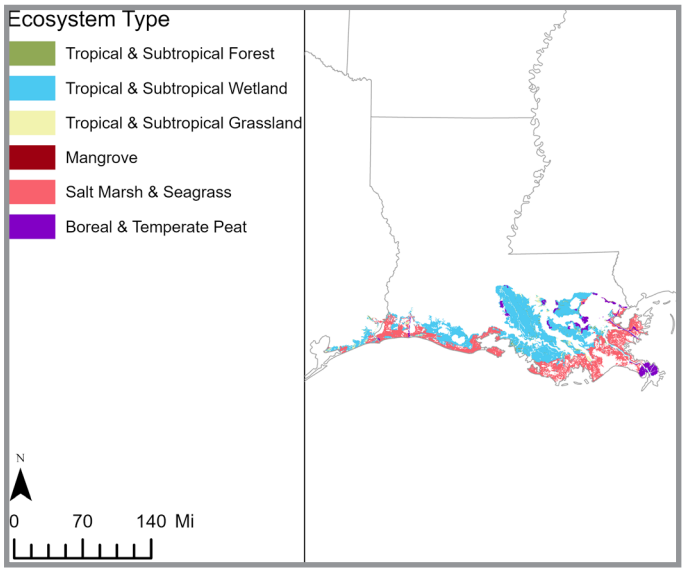


Figure 2: Ecosystem of IRC in the Gulf Coast HCA.

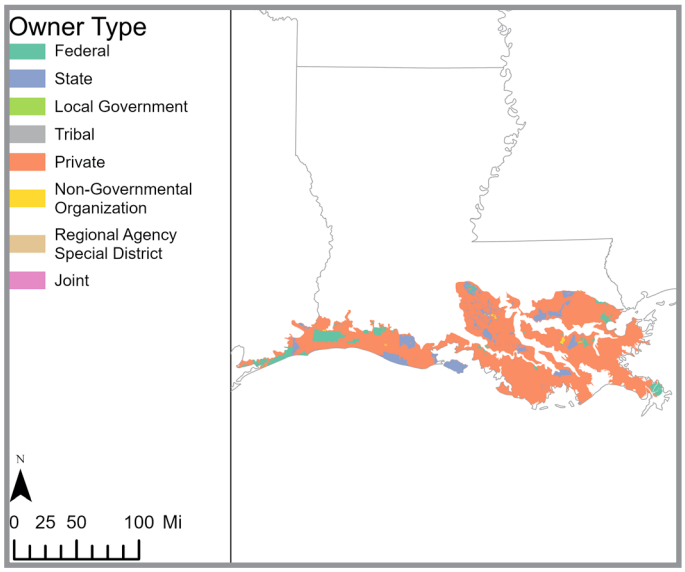
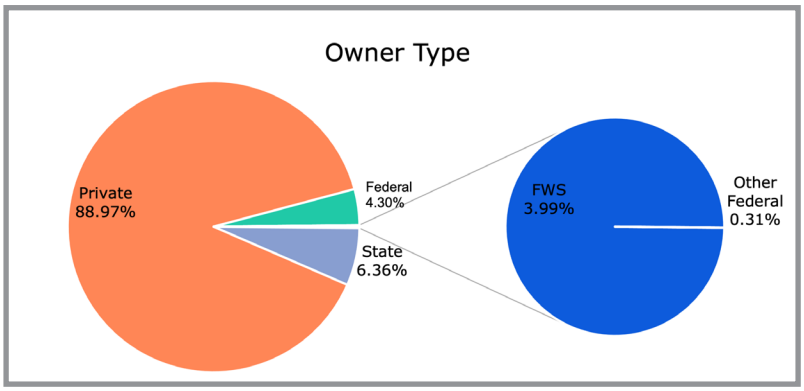


Figure 3: Owner type of IRC in the Gulf Coast HCA.

- There is a need for better protection for mangroves outside of Florida.
- IRC is extremely vulnerable in this region, yet large tracts of undeveloped "blue carbon" still exist - these carbon "hot spots" are high priority conservation areas.[201]

PATHS TO INCREASED PROTECTION

- Since the majority of IRC is private, the best paths to increase IRC protection rest with appeals to private landowners and municipalities:
  - Work to change zoning laws so that floodplains and delta areas remain undeveloped and resilient to sea level changes and flooding.[202]
  - Greater use of Clean Water Act Section 404 mitigation across Louisiana and Texas could further increase wetland protection when development inevitably occurs.
  - Utilize FEMA post-disaster funds to acquire and restore marshland.[203]
  - Work to leverage 30 by 30 to increase protection and engage landowners.
- Leverage federal policy to reconnect Mississippi River watershed to restore health of Delta and aid in averting sea-level rise and use nature-based solutions, rather than trying to fix it in the short-term through dams and concrete.[204]
  - NOAA's Coastal Resilience program shows promise for funneling money to marsh protection in the region.
  - Billions of dollars for coastal resilience and conservation projects in the Bipartisan Infrastructure Law and the Inflation Reduction Act.
- A carbon tax could be a valuable incentive for IRC conservation. However, because the area is conservative, a voluntary carbon market is not a viable solution because people would be unlikely to opt in, thus it would need to be federally imposed.[205]
- Work to integrate and streamline the myriad coastal resilience projects already underway to have a cohesive and economically efficient wetlands protection plan for the region.[206]
- Communication strategies for NGOs, land conservancies, and government agencies to enhance IRC protection include:
  - Taking advantage of environmental catastrophes in the region to motivate policy and behavior change from the general



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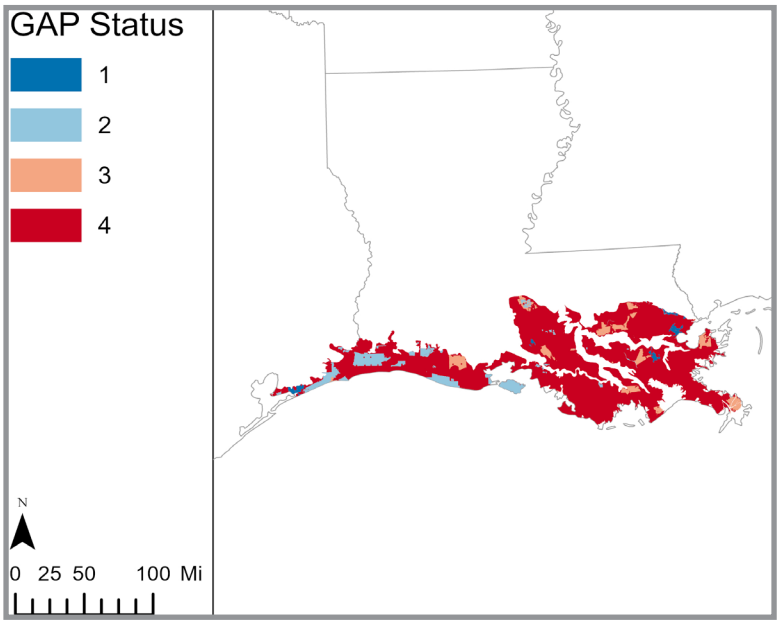
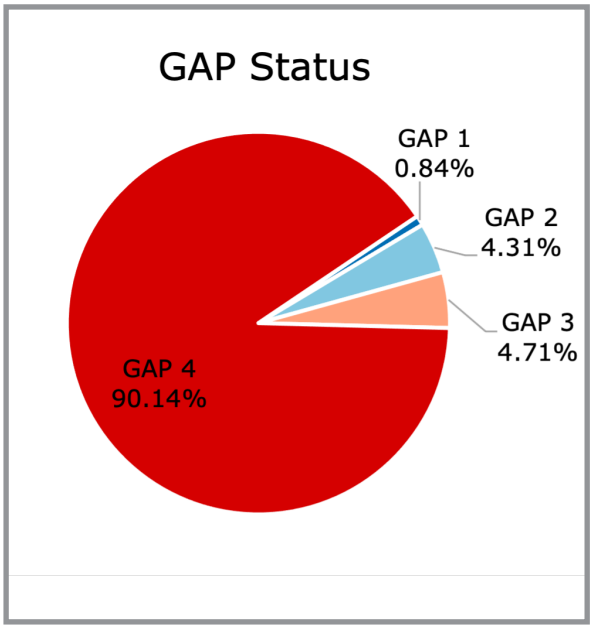




Left - Figure 5: GAP Status of IRC in the Gulf Coast HCA; **Right - Figure 6:** Breakdown of GAP Status of IRC in the Gulf Coast HCA.

public and decision-makers.[207]

- With landowners, use risk-based framing and emphasize how protections offer solutions. For example, leverage the relationship between marshes and increased storm resilience to encourage protection.
- With decision makers, frame protection as nature-based climate solutions.

- Avoiding politically charged labels, like climate change, Green New Deal, and 30 by 30 when interacting with landowners. Instead focus on co-benefits, such as storm surge buffers and enhanced water quality. Strive to align messaging with local values.[208]
- Focusing on regional implementation by local governments, community groups, and trusted local leaders since the population is suspicious of top-down federal policy.[209]
- While there remains a degree of climate change denial, extreme weather events have resulted in slow shifts of landowner perspectives – potentially creating an opening to use economic incentives to encourage carbon protection.[210]

Sabine Wetlands, LA, LA Tourism Locations & Events - Flickr Creative Commons.[211]

High Carbon Area:

NORTHEAST

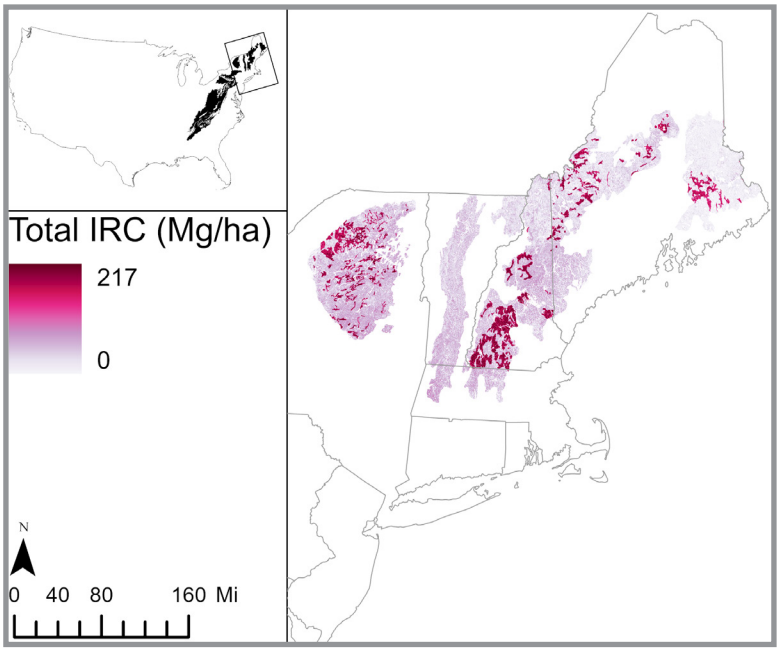


Figure 1: Total IRC in the Northeast HCA.

HCA GEOGRAPHIC AND CULTURAL CONTEXT

- The HCA spans New York, Vermont, Massachusetts, New Hampshire, and Maine with IRC concentrated in NY's Adirondack Mountains, VT's Green Mountains, NH's White Mountains, western MA, and western and mid-eastern ME.
- HCA crosses over the present day and ancestral lands of Indigenous peoples including the Mohawk (Kanien'kehá:ka), N'dakina (Abenaki), Wabanaki, Ho-de-no-sau-nee-ga (Haudenosaunee), Mohican, Nanrantsouak, Passamaquoddy, and Penobscot peoples.
- Rural areas are more conservative and overlap with higher concentration of IRC. While the voter base is generally liberal and likely to support conservation policy and goals, key populations are likely to connect more with co-benefits of conservation such as hunting or outdoor recreation rather than carbon sequestration or conservation itself.
- Populations in all five states in this HCA have been rising over the past decade, creating dispersed settlement patterns, leading to habitat fragmentation and carbon release.[212]
- The agriculture and timber industries in VT and ME are the most closely tied to IRC.
  - Agriculture in VT and ME makes up 4.5% and 4.9% of state GDP, respectively.[213]
  - Timber contributed $2.1 billion and $8 billion to the state economies of VT and ME in 2019, respectively.[214, 215]
  - Tourism, especially outdoor recreation tourism, is also a significant industry across the states in this HCA, making up 4.6%, 3.6%, and 2.7% of state GDP for VT, ME, and NH, respectively.[216]

IRRECOVERABLE CARBON OVERVIEW

- IRC ownership is predominantly private (69.2%), then state (18.9%), and federal (5.5%).
- The region holds over 565 megatonnes of carbon; its IRC density is the fifth highest among the nation's ten HCAs.
- Ecosystem types span eastern temperate forest to northern hardwood or boreal. The Maine woods is one of the most densely forested areas of the continental U.S. and one of the largest, most contiguous, highest ecologically connective forests east of the Rockies.[217]
- IRC is found mostly in above ground biomass with 68.6% of IRC found in biomass and 31.5% stored in soil carbon.
- Notable co-benefits of landscape conservation include habitat conservation, ecological connectivity, and protection of wildlife. While outdoor recreation, hunting, and biodiversity are more often discussed as benefits of conservation, carbon sequestration has slowly begun to be considered due to changes in state-level government administrations and pressure from conservation organizations.[218]

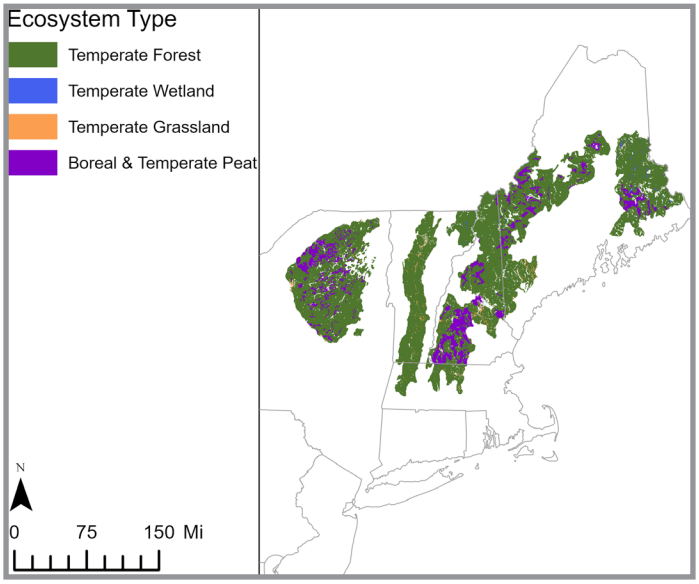


Figure 2: Ecosystem of IRC in the Northeast.

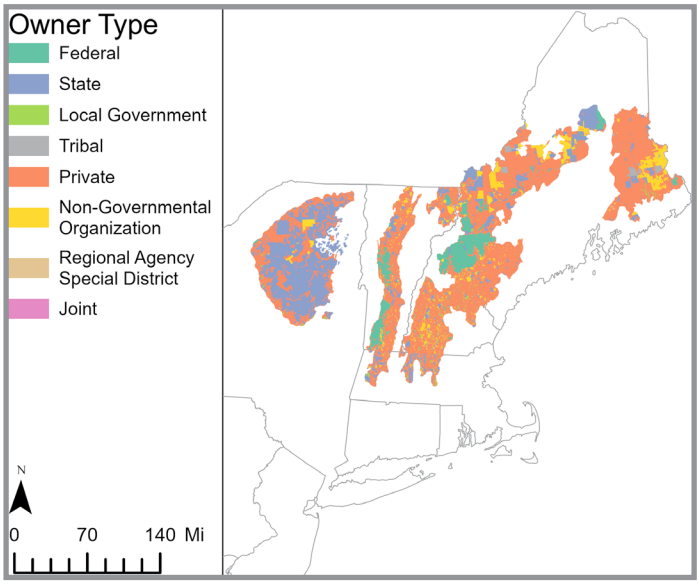


Figure 3: Owner type of IRC in the Northeast.

IRC PROTECTION & THREATS

- IRC has limited formal protections due to the high proportion of privately owned, forested land. The majority of IRC falls under GAP 4 status (74.8%).
  - Adirondack State Park, the Green and White Mountain National Forests, and Baxter State Park are in the GAP 1 and 2 status categories.
- While 4.7% of IRC is managed by non-profits including land trusts, the level of protection provided to IRC is unclear due to the dynamic nature of conservation easements.
- Private land protection and management beyond that of land trusts and conservation easements is dominated by the timber industry, followed by agriculture.
  - In ME, timber companies use working forest easements – collaborative agreements to "prevent development and maintain forest diversity".[219] The largest motivator for companies to protect certain areas is financial, leading to an interest in carbon markets.
    - Additional state initiatives to increase incentives for "high-quality, on-the-ground performance by loggers" around climate-friendly harvesting practices have been enacted, including cost-sharing resources to support companies in transitioning to more sustainable, carbon-focused management practices.[220] State legislatures have also initiated studies of forest carbon market entry and carbon accounting protocols.[221]
- The primary threats to IRC are development, forestry (in ME and VT), and agriculture.
  - The largest immediate threat is development and encroaching towns and buildings in rural and forested areas.
  - For example, an estimated 10,000 acres of natural and working lands are being lost to development each year in Maine.[222]
  - Natural disasters such as microbursts, droughts, and wildfires, are limited but existent and expected to increase with climate change. Experts in the region anticipate future wildfire risk despite it being limited so far.

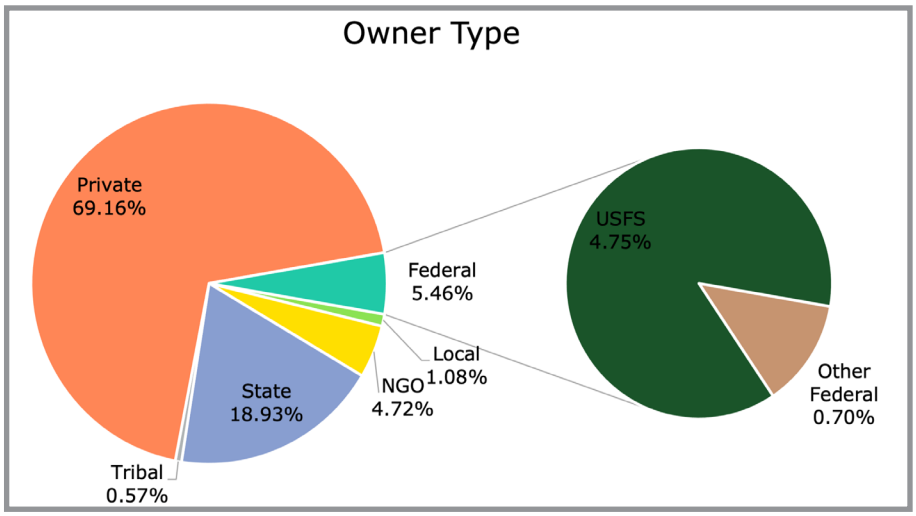
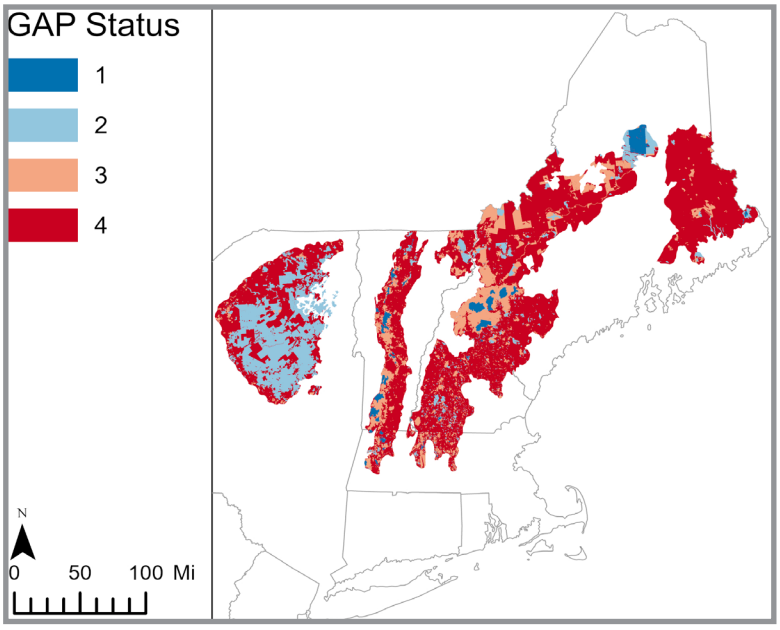
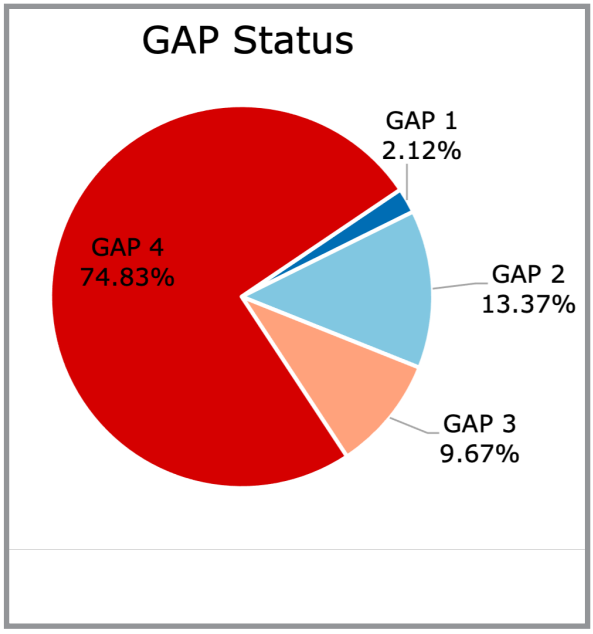


Figure 4: Owner of IRC with federal ownership split into agencies.





Left - Figure 5: GAP Status of IRC in the Northeast; **Right - Figure 6:** Breakdown of GAP Status of IRC in the Northeast.

- "The forests are young, but they are poised to grow and pull up a lot of carbon" – the idea being that enhanced forest management may improve carbon sequestration.[223] The timber industry in this region is somewhat engaged in improving sustainable management practices as well as determining carbon credit markets where feasible. In some cases, companies are working with state agencies to develop a forest carbon program to incentivize increased carbon storage.[224]

PATHS TO INCREASED PROTECTION

- Concurrent implementation of multiple approaches to address threats and expand protection of IRC will be most effective in increasing protection.
- The goal should be to build on existing public and private forest lands – primarily state, private (corporations and individuals), and nonprofit easements on private property (land trusts) –, encourage increased protections and identify new areas for conservation, such as areas along development corridors or at highest risk of conversion.
- Coordination across states with efforts like the "Securing Northeast Forest Carbon Program" – a cooperative of state forestry offices to protect as much private forest carbon as possible in the region by 2024 – can be used to change management through education and outreach to public and private forest managers, landowners, and land trust communities across seven states in the Northeast (including two outside this HCA).[225]
- The only current active carbon management in the region is where large landowners have sold carbon credits, a trend that has been slowly increasing since 2010.[226]
  - Under the Regional Greenhouse Gas Initiative – a joint initiative of Eastern States to reduce greenhouse gas emissions – forestry and afforestation are key offset options for industrial emitters looking to buy offsets.[227]
  - In VT, The Nature Conservancy is working with small-scale landowners (100 acres or less) to create forest carbon co-ops so smaller landowners can access emerging carbon markets and carbon-focused management is incentivized.[228]
  - In Maine, groups ranging from land trusts to timber companies, to the Passamaquoddy Tribe, have taken advantage of carbon markets to raise funds for conservation and, in some cases, avoid selling for development.
    - The Downeast Lakes Land Trust sold $4 million worth of carbon credits on California's carbon offset market to finance a land purchase in 2016.[229]
- Given that landowners need money or resources to protect land rather than sell or develop it, increasing fiscal incentives for private landowners can be effective in protecting IRC.
  - One example is MA's increased tax incentives for private land conservation.
  - At the federal level, USDA's Environmental Quality Incentives Program provides Conservation Innovation grants to farmers and forest landowners to improve conservation practices.[230] Similarly, USFS's Forest Stewardship Program provides private landowners with resources to manage forests more sustainably.[231]

- Creating state- or local-level change around town planning and development: Strategic town planning and foresight to anticipate expansion can help slow deforestation and protect the most intact forests, especially around the northern forests in VT and ME.
    - For example, in Maine, non-profits have been involved in advising and serving as watchdogs for the state Land Use Planning Commission.[232]
- An effort to work with private landowners, particularly timber companies in ME and VT, to change forest management practices to focus on aspects like habitat connectivity, tree diversity, carbon sequestration, or stand age optimization will be crucial.[233] There is a huge opportunity to preserve the contiguous forest by working with the timber industry.[234]
    - While in Maine, for example, 30% of forest land is owned by REITs and TIMOs, "family owners" own almost the same amount of land. Smaller landowners may be more interested in conservation easements or other conservation measures. Additionally, with the decline of the paper and timber industry, opportunities for conservation organizations to purchase former timberland have increased in recent years.[235]
- The most important constituency to have engaged will be communities and individual conservation and community leaders.
    - Organizations have succeeded in moving climate and conservation goals forward with efforts that engage local communities. For example, Maine's Climate Strategy (Maine Won't Wait), driven by the Governor's Office, offers a clear and comprehensive strategy for the state – including increasing carbon sequestration – and was established through a stakeholder process that focused on community needs and practical, voluntary actions.[236]

White Mountain National Forest, courtesy of USFS - Flickr Creative Commons.

APPENDICES

A. GIS METHODS

IDENTIFYING HIGH CARBON AREAS (HCAS)

High carbon areas (HCAs) were identified through a quantitatively constrained group process. The primary objective in delineating HCAs was to identify spatially distinct areas of high IRC across the U.S. for further qualitative analysis. We adapted methods from a prior study which used a team of natural resources experts to identify visual discontinuities in raster data at a national scale to delineate priority landscapes (Belote et al., 2021).[237] The first step in our process was to extract IRC raster data to EPA ecoregions. We chose the finest scale EPA ecoregions (level IV in the continental U.S. and level III in Alaska) to delineate our HCAs because they are the standard spatial unit that federal and state agencies use to structure environmental assessment, management, and research programs across the United States (Omernik & Griffith, 2014).[238] IRC is defined by its manageability and vulnerability to release due to land use change, so extracting the data to a common unit of manageability seemed most appropriate (Noon et al., 2022).[239]

After extracting the IRC data to the ecoregions, the ecoregions were symbolized using a Jenks Natural Breaks classification method (n=5) in ArcGIS Pro™ (ESRI). The two highest breaks (ecoregions with IRC ≥ 1.89 Mt) were selected as foundational ecoregions to build our HCAs upon. This captured approximately the top 10% of ecoregions (91.3 percentile) with the greatest concentration of IRC, and contained 56.21% of total IRC in the continental U.S.

For Alaska, Level III Ecoregions were symbolized using a Jenks Natural Breaks classification method (n=5) in ArcGIS Pro™ (ESRI). Again, the top two breaks were selected to construct an HCA for Alaska. This HCA captured the top 10% of ecoregions with the greatest concentration of IRC (90 percentile), and 48.56% of all IRC in Alaska.

Final HCAs were derived through a group process. As in Belote et al. 2021, the 10-person team represented expertise in ecology, large-landscape conservation, geospatial data science, social dimensions of natural resource management, and natural resources policy. Based on visual discontinuities between ecoregions of high IRC, the team identified 10 spatially distinct HCAs based on the two highest breaks in the ecoregion/IRC data. From these bare bones regions, the team iteratively built up each HCA by including additional ecoregions to improve spatial continuity or capture important landscapes for further qualitative analysis, and omitting ecoregions that were not of interest for additional qualitative analysis.

Our delineation process incorporated both quantitative and subjective components and was successful at establishing logical contiguous regions for further analysis. Further spatial analysis was undertaken at a finer scale, so although the HCA boundaries may have little scientific value, the survey of land within each HCA remains valid.

ASSESSING LAND OWNERSHIP AND MANAGEMENT CHARACTERISTICS OF HCAS

To assess the ownership, management, and current protection of IRC in the U.S., data from the U.S. Geological Survey Protected Areas Database 3.0 (PADUS) was employed. PADUS is the most comprehensive, constantly updated dataset on land protection land use characteristics for the U.S. First, PADUS data was extracted to the boundaries of the HCAs.

Next, overlapping boundaries in polygons were resolved to facilitate the calculation of zonal statistics. We employed the exact procedure the USGS uses to produce their own vector analysis data product, where the highest priority in resolving overlaps is given to the boundary with the most protected GAP status.[240] Unit name, management type/name, ownership type/name, GAP status, public access, and designation type were preserved for further analysis.
After flattening the data, zonal statistics were computed to extract the sums of biomass, soil, and total IRC within each boundary using a cell center method. The resulting sums were converted from a relative value (Mg/ha) to an absolute value (Mg) by multiplying concentrations by boundary areas.

An analysis of error was also carried through from the IRC data. A layer quantifying standard error of estimated IRC was extracted to each boundary using the above methods. Final standard error for each boundary was computed through a root sum of squares.

Based on USGS PADUS data and metadata, we used the data category "Manager Type" as a proxy for and the most accurate representation of land ownership. As stated in the metadata for the dataset, "Use the 'Manager Type' field for the best general depiction of federal lands…as several ownership related data gaps occur…"[241] We tested use of other ownership data and found that using this assumption – manager type for ownership – resulted in the most accurate representation of land ownership.

B. ADDITIONAL TABLES & GRAPHS

High Carbon Area (HCA)	HCA Acreage	Total IRC (Megatonnes)	Density of IRC (IRC Mg/acre)	% IRC in Biomass	% IRC in Soil	Primary Ecosystem Types
Alaska	180,748,800	1,521.69	8.42	48.81%	51.19%	Boreal forest, grassland, wetland, and peatland
Appalachia	67,866,660	1,424.99	21	99.97%	0%3%	Temperate forest and grassland
PNW	37,629,870	1,285.63	34.17	99.76%	0.24%	Temperate forest (coniferous), grassland
Northeast	18,929,380	565.3	29.86	68.55%	31.45%	Temperate forest, peatland
Northern MN / U.P.	16,628,800	522.36	31.41	7.52%	92.48%	Peatland, temperate forest, and grassland
Northern Rockies	24,817,590	450.37	18.15	99.86%	0.14%	Temperate forests (coniferous), grassland
Carolina Coast	17,275,710	355	20.55	7.57%	92.43%	Subtropical forest, wetland, peatland, and salt marsh
South Florida	4,738,734	317.44	66.99	0.79%	99.21%	Peatland, wetland, mangroves, subtropical forest
Gulf Coast	7,011,992	311.01	44.35	4.48%	95.52%	Wetland, salt marsh, and peatland
Sierra	2,288,276	30.83	13.47	99.95%	0%5%	Forest (Redwoods, southern conifers), grassland

Table 1: HCA physical and ecological characteristics calculated using GIS analysis. HCA listed in order of total IRC stored.

HCA	Alaska	Appalachia	Coastal Carolinas	Gulf Coast	Northeast	Northern MN / U.P.	Northern Rockies	PNW	Sierra	South Florida
Boreal Forest	**42.70%**	0%	0%	0%	0%	0%	0%	0%	0%	0%
Boreal Grassland	**37.00%**	0%	0%	0%	0%	0%	0%	0%	0%	0%
Boreal Wetland	3.10%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Boreal & Temperate Peatland	**8.70%**	0%	**14.60%**	**5.90%**	**12.00%**	**39.90%**	0%	0%	0%	0%
Temperate Forest	**6.60%**	**82.30%**	0%	0%	**86.50%**	**32.60%**	**85.50%**	**88.90%**	0%	0%
Temperate Wetland	0.50%	0.10%	0%	0%	0.40%	**22.90%**	0.50%	0.20%	0%	0%
Temperate Grassland	1.50%	**17.60%**	0%	0%	1.10%	**4.50%**	**14.00%**	**8.50%**	0%	0%
(Sub) Tropical Forest	0%	0%	**49.20%**	1.9	0%	0%	0%	2.20%	**97.60%**	**8.30%**
(Sub) Tropical Wetland	0%	0%	**24.30%**	**53.60%**	0%	0%	0%	0%	0%	**34.60%**
(Sub) Tropical Grassland	0%	0%	3.1	2.3	0%	0%	0%	0.10%	2.40%	2.20%
Mangrove	0%	0%	0%	0%	0%	0%	0%	0%	0%	**11.60%**
Salt Marsh and Seagrass	0%	0%	**8.70%**	**36.20%**	0%	0%	0%	0%	0%	2.30%
Tropical Peatland	0%	0%	0%	0%	0%	0%	0%	0%	0%	**41.10%**

Table 2: Percent of HCA in each ecosystem type. Top four ecosystem types for each HCA (if 5% or greater) are in bold. Top two ecosystem percentages are in yellow.

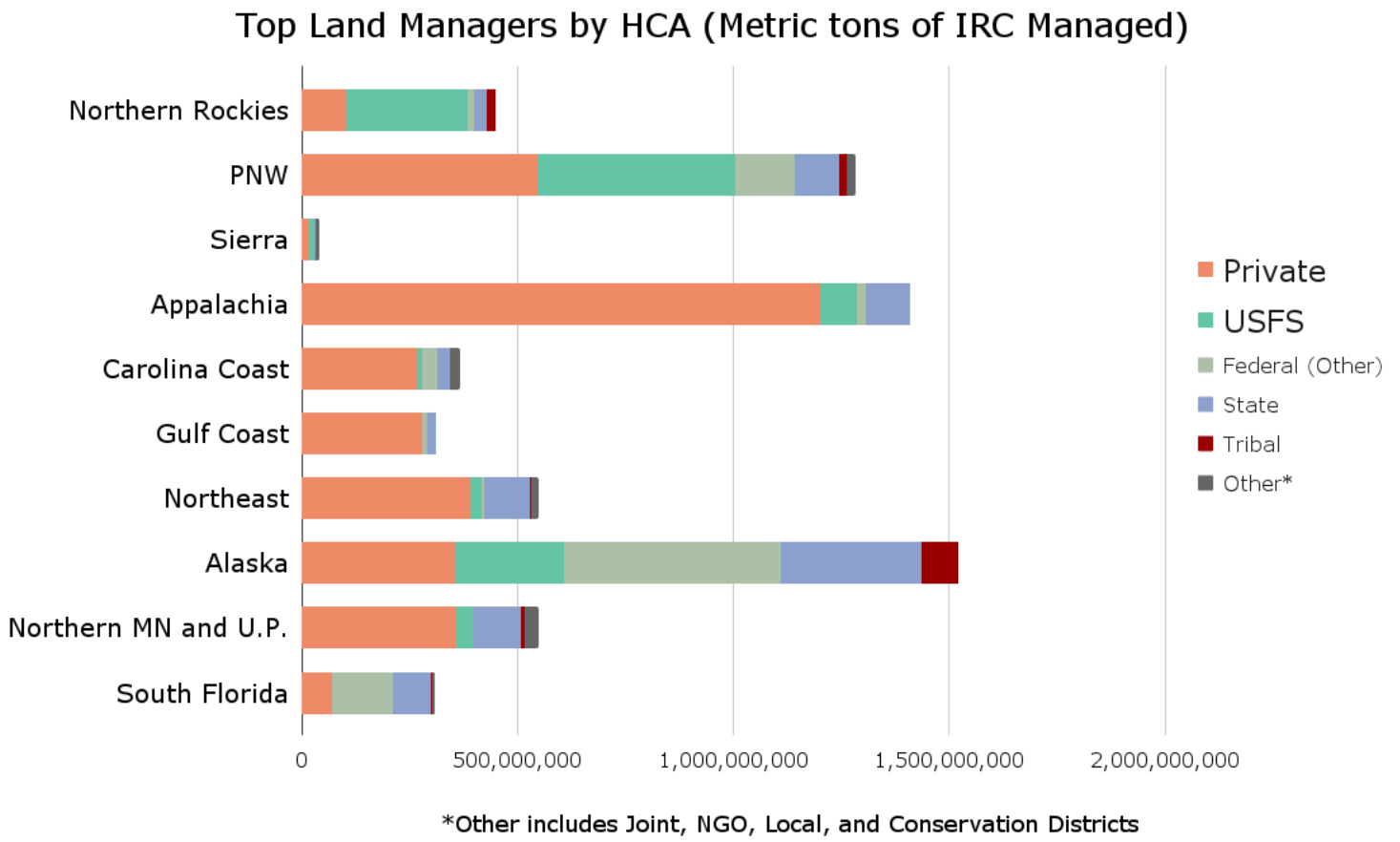


Figure 1: Top IRC Managers by HCA aggregated into Private, Federal, State, Tribal, and Other, with USFS separated from other Federal managers to highlight large quantities of IRC managed relative to other entities.

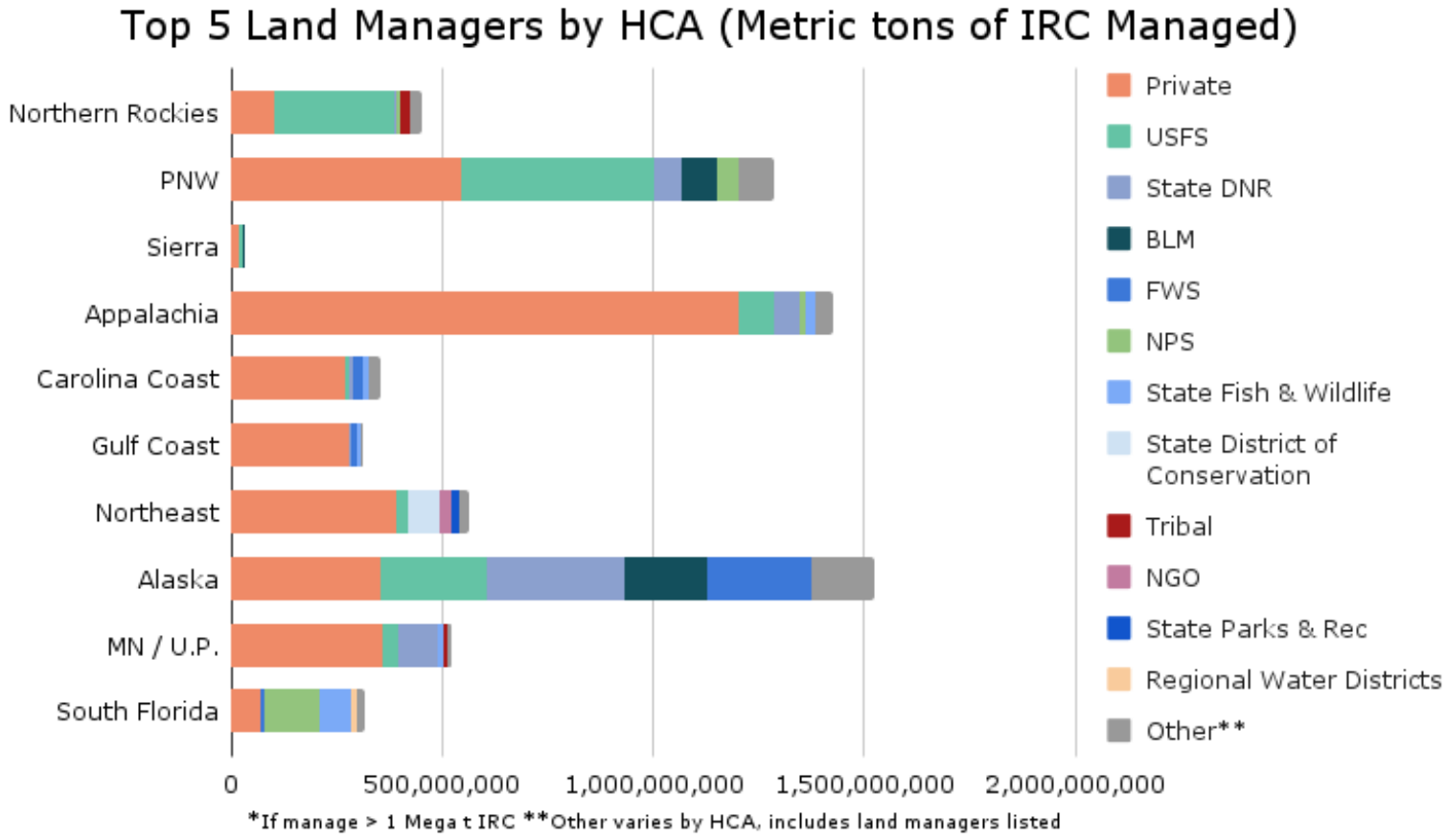


Figure 2: Top 5 Land Managers by HCA in terms of quantity of IRC managed, if they manage more than 1 megatonne IRC.

C. EXPLANATION OF KEY TERMS

IRRECOVERABLE CARBON (IRC)

IRC describes dense stores of above- and below-ground carbon, sequestered in biomass and soil over decades to millennia, that are vulnerable to release into the atmosphere by human activities. If released, this carbon will not be restored or naturally re-sequestered by 2050, the point at which the world must reach net-zero emissions to avoid the worst consequences of climate change.[242] It is commonly measured in megagrammes (Mg), with Mg per hectare or acre used for density. In this report, you will also find IRC measured in megatonnes, where 1 million megatonnes is equal to 1 Mg.

Biomass IRC: Aboveground biomass; including plant stems, trunks and leaves) plus belowground biomass (including roots).

Soil IRC: Soil organic carbon (SOC) to a depth of 30 cm for upland mineral soils and 1 m for waterlogged peat and coastal systems.

HIGH CARBON AREA (HCA)

We identified 10 High Carbon Areas (HCAs) across the country using a quantitatively constrained group process that prioritized high concentrations of IRC as well as ecologically distinct landscapes. The primary objective in delineating HCAs was to identify these spatially distinct areas of high IRC across the U.S. in a way that enabled further qualitative analysis by HCA. See the appendix for additional information of the geospatial methods that were applied (Appendix A).

GAP STATUS

GAP Status Codes are used to describe the "measure of management intent to preserve biodiversity" of land areas. GAP Status 1 and 2 indicate lands that are permanently protected from conversion and have mandated natural land management plans in operation. GAP status 3 lands have a degree of permanent protection from land conversion, but are subject to extractive use (like timber harvesting, ORV usage, or mining). GAP status 4 areas have no known permanent protections against land conversion.

- GAP Status 1 - Areas managed for biodiversity where natural disturbances are allowed to proceed.
- GAP Status 2 - Areas managed for biodiversity where natural disturbance is suppressed
- GAP Status 3 - Areas protected from land cover conversion but subject to extractive uses such as logging and mining.
- GAP Status 4 - Areas with no known mandate for protection.[243]

OWNERSHIP

Based on USGS PADUS data and metadata, we used the data category "Manager Type" as a proxy for and the most accurate representation of land ownership. As stated in the metadata for the dataset, "Use the 'Manager Type' field for the best general depiction of federal lands...as several ownership related data gaps occur..."[244] We tested use of other ownership data and found that using this assumption – manager type for ownership – resulted in the most accurate representation of land ownership.

D. TWS SPECIFIC RECOMMENDATIONS FOR HCAS

Table 1 shows the extent to which the High Carbon Areas identified through this study overlap with TWS priority landscapes. In this section, we provide greater detail about where overlaps occur. To best leverage pre-existing relationships and resources, TWS should focus on efforts in the areas in which they already work. However, we also encourage TWS to be on the lookout for opportunities to influence IRC policy and protection in non-priority areas where, in some cases, IRC is more vulnerable and/or conservation efforts will result in a greater amount of carbon protected.

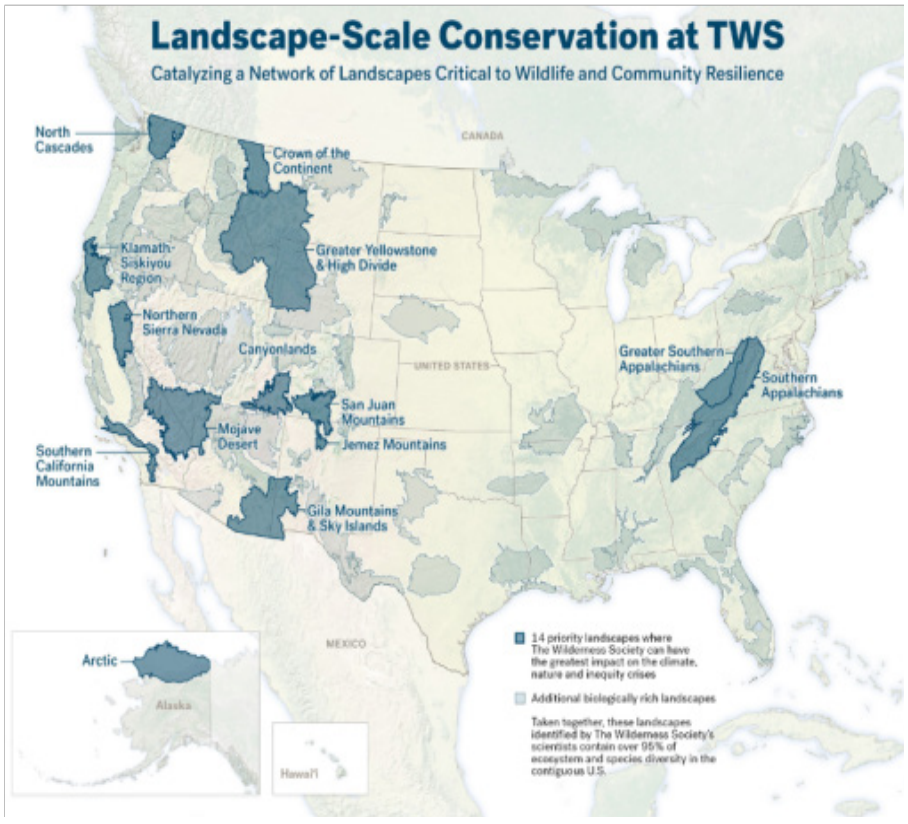
HCA	% Overlap	TWS Priority Area	Priority (based on UM team analysis)
Alaska	23%	Arctic	Low
Appalachia	39%	Greater Southern Appalachians and Southern Appalachians	High
Carolina Coast	0%		Medium-High
Gulf Coast	0%		Medium-Low
Northeast	0%		Low
Northern MN/UP	0%		High
Northern Rockies	28%	Crown of the Continent and Greater Yellowstone & High Divide	Medium-High
PNW	9%	North Cascades and Klamath-Siskiyou	High
Sierras	100%	Northern Sierra Nevada	Medium-High
South Florida	0%		Medium-Low

Table 1: Extent of overlap between identified High Carbon Areas and TWS Priority Landscapes. The percentage given is the amount of the HCA that falls within the TWS priority landscape.

TWS-SPECIFIC DETAILS FOR HCAS WITH OVERLAP

Pacific Northwest (High Priority)

The Pacific Northwest HCA overlaps two important TWS priority landscapes: North Cascades and Klamath-Siskiyou. It also overlaps seven other TWS landscapes: Blue Mountains, North Coast Ranges, Olympics, Oregon Cascades, Pumice Plateau, Redwood Coast Range, and Wallowas. While approximately 9% of the HCA is found in either of the two priority landscapes, 91% of the HCA is currently not found within a TWS priority landscape and is therefore not currently in the scope of current TWS campaign efforts. However, TWS should consider expanding its efforts to these areas given the proximity to work already taking place within the organization. For example, TWS staff already oversee projects relating to the North Cascades Initiative in Washington to preserve old-growth forests and combat unsustainable industry practices – these efforts directly protect IRC.



Northern Rockies (Medium-High Priority)

The Northern Rockies HCA overlaps two TWS priority landscapes: the Crown of the Continent and the Greater Yellowstone & High Divide. It also overlaps two other TWS landscapes: Clearwater and the Central Idaho Ecosystem. While approximately 28% of the HCA is found in either of the two priority landscapes, 72% of the HCA is currently not found within a TWS priority landscape and is therefore not

currently in the scope of current TWS campaign efforts. The Northern Rockies Advocacy Memo and case study provides actionable steps for TWS to take both within and outside of its priority landscapes in this region.

Sierra (Medium-High Priority)

The Sierra HCA is entirely contained within the TWS Northern Sierra Nevada priority landscape. Thus, TWS should be well-positioned to include a focus on IRC in its conservation efforts in that region. Recommendations for IRC protection actions that TWS should pursue are outlined in the Sierra Case Study, found earlier in this report.

Appalachia (High Priority)

The Appalachia HCA overlaps with two TWS priority landscapes: Greater Southern Appalachians and Southern Appalachians. It also overlaps the Cumberland Mountains and Allegheny Plateau TWS landscapes. While approximately 39% of the HCA is found in either of the two priority landscapes, 61% of the HCA is currently not found within a TWS priority landscape and is therefore not in the scope of current TWS campaign efforts.

ADDITIONAL NOTES FOR TWS ON HCAS WITHOUT OVERLAP

Northern MN / U.P. (High Priority)

The Northern Minnesota / U.P. HCA does not lie within any TWS priority landscapes or regional offices. The HCA does, however, overlap with a region that TWS has identified as a biologically rich landscape.[245] The organization has written several articles opposing proposed mines near the Boundary Waters Canoe area, which lies adjacent to the HCA but not inside its boundaries.[246]

Carolina Coast (Medium-High Priority)

The Carolina Coast HCA does not overlap with TWS priority landscapes, though the region has been identified as a biologically rich landscape by TWS. Due to the need for grassroots IRC conservation efforts in this region, TWS should leverage its relatively larger financial, political, and scientific resources to support local efforts. Possible actions TWS could take to support smaller-scale efforts in the Coastal Carolinas include:

- Embedding a researcher in the area who is well-connected to the population and can help support efforts on coastal resilience, water quality, salt marsh restoration, and similar.
- Advocating at the state-level for land-use and zoning changes that can be implemented that would result in protection of IRC. This top-down approach, however, will only be effective if TWS has a local presence in the area.
- Engaging in outreach efforts to key stakeholders, like oyster farmers, coastal business owners, and private landowners through community engagement and communication. This, in addition to embedding researchers in the area, could look like showing up to local events, financially supporting local conservation efforts, engaging with existing after-school programs and other groups to engage area youth, and similar.

Though TWS is a wildlands conservation organization and is less concerned with private land issues, there's a distinct opportunity to participate in essential wetland restoration projects and conservation measures that will have a tangible, positive impact for the area's population and IRC protection.

South Florida (Medium-Low Priority)

The HCA is currently not a part of TWS's Priority Areas. However, it does overlap with a TWS non-priority landscape: the Everglades. Rather than allocate resources into the establishment of TWS in this region, it would be most effective and efficient to collaborate with established environmental groups and initiatives in the greater Gulf Coast region to (a) spread awareness, educate, and engage stakeholders as well as (b) advocate for increased funding and resources.

Gulf Coast (Medium-Low Priority)

The Gulf Coast HCA also contains an area identified as biologically rich by TWS. Because of similar population characteristics and needs related to IRC conservation, TWS-specific efforts in this region should be similar to those taken in the Carolina Coast HCA (see above). Other large conservation groups, like The Nature Conservancy, have already undertaken significant efforts in this area.

Alaska (Low Priority)

Approximately 23% of the HCA is found in the TWS Arctic Priority Landscape. Because the greatest threats to the IRC stored in Alaska

are changes to federal conservation policy, TWS has a critical role to play in leveraging its already strong political presence in D.C. to ensure that the current protections to the Tongass National Forest and other Alaskan wilderness areas remain in place.

Northeast (Low Priority)

There is no overlap between the Northeast HCA and a TWS priority landscape. However, it also contains parts of TWS-identified "biologically rich landscape." In this area, to influence IRC protection TWS should focus on collaboration with land trusts and local landowners rather than trying to start its own efforts. As one interviewee discussed, one of the most effective approaches to increasing long-term protections in the region would be building a network of nonprofits to accelerate efforts educating and working with landowners, expanding conservation easements, and supporting state-level policies to increase protections. Because local landowner engagement is the specialty of other non-profits like the Trust for Public Land, this approach may look more like building a coalition of regional groups to support this work together and leverage each group's strengths.

Additionally, because development is one of the largest threats, we would recommend that TWS focus on changing state (and possibly local) level policies to change zoning and town planning processes to prioritize forest conservation.

E. STUDY LIMITATIONS

GIS Data Analysis

We used USGS PADUS data to calculate the amount of IRC owned and managed by state and federal entities. The data does not clearly delineate "private" land ownership, and instead has a small category of corporately owned private land (PVT) and designates a large amount of land as Unknown (UNK). Following CBIs "private unprotected lands matrix" methodology, we assumed that all Unknown land is Private. This means that our private IRC is likely a small overestimate from the actual value.[247]

Interviews

We conducted 40 interviews total with experts from across the United States. However, our number of interviewees was not evenly distributed across the HCAs, meaning that we have greater depth in some regions as compared to others. Additionally, our interviewees work at varying scales of conservation – in some cases, we gained very place-specific perspectives, while in others we spoke with state or federal level experts. Thus, we have varying ability to make recommendations that scale down to the local level and/or up to statewide and federal policy. Finally, while many of our interviewees spoke at length about tribes, we were unable to speak directly with Indigenous-identifying individuals.

Areas of Future Research

Our work is the first effort to characterize IRC across the United States, thus there is great potential for future research. Suggested topics to explore more deeply include:

- Tribal perspectives on and approaches to carbon conservation and management.
- USFS carbon management: strategies for implementing effective carbon management practices on USFS land.
- Carbon markets: exploring the potential for carbon credits to incentivize IRC protection.
- Wetlands and peatland HCAs: in-depth analysis of how to increase IRC protection in the HCAs with relatively carbon-rich wetland and peatland ecosystems.

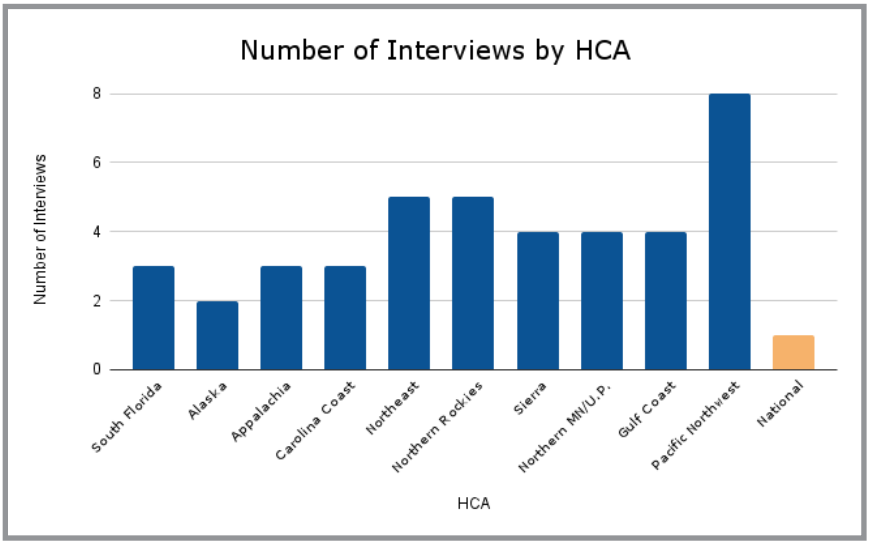


Figure 1: Number of interviews conducted in each HCA by SEAS team. Includes one national-scale interview.

ENDNOTES

1 https://www.nature.org/en-us/about-us/where-we-work/priority-landscapes/emerald-edge/
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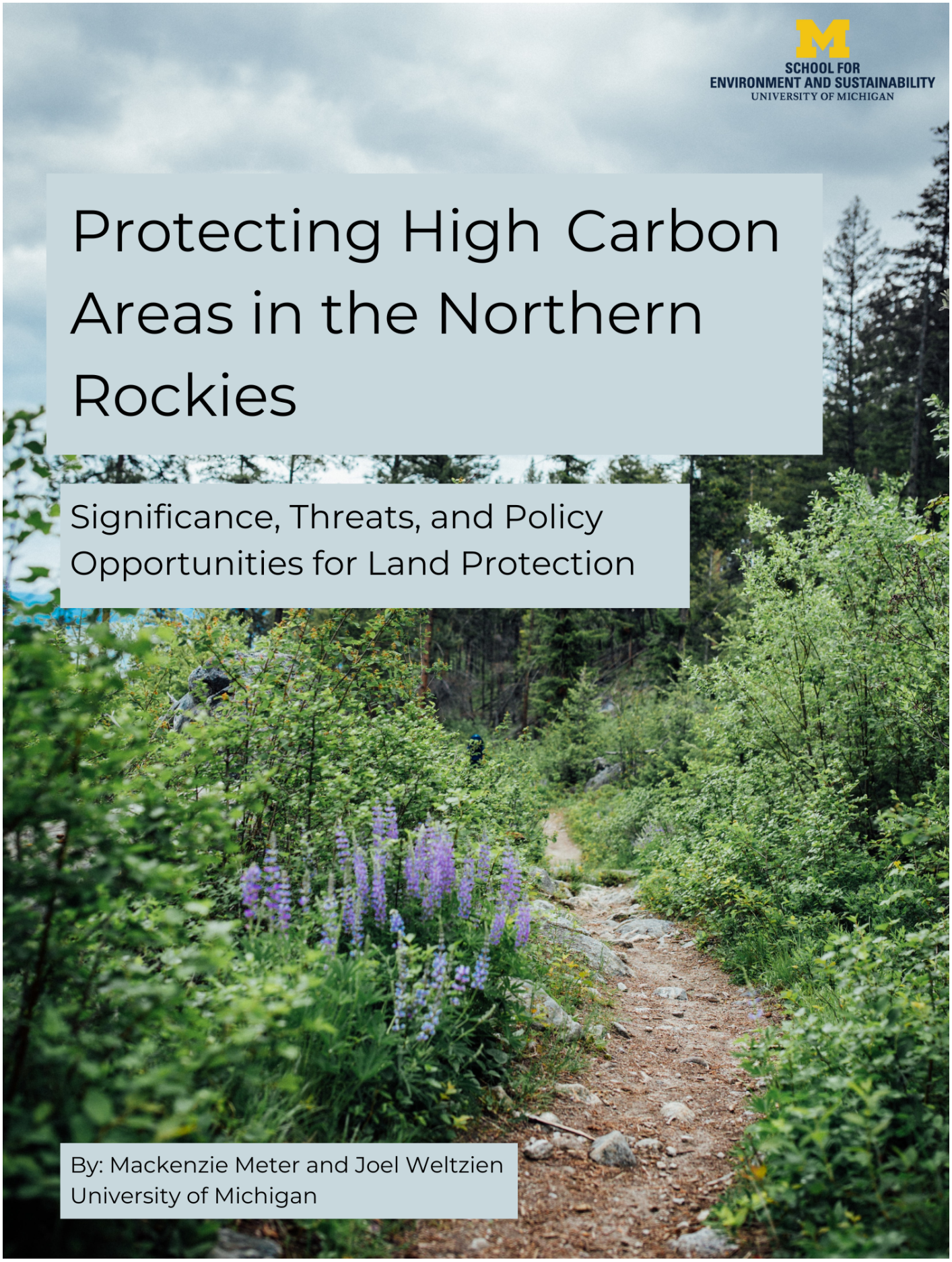

SCHOOL FOR ENVIRONMENT AND SUSTAINABILITY
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Protecting High Carbon Areas in the Northern Rockies

Significance, Threats, and Policy Opportunities for Land Protection

By: Mackenzie Meter and Joel Weltzien
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To whom it may concern:

Irrecoverable carbon (IRC) is a classification of carbon researched and first introduced by Allie Goldstein et al (2020, *Nature Climate Change*)[1] and mapped by Monica Noon et al (2021, *Nature Sustainability*).[2] It describes dense stores of above- and below-ground carbon, sequestered in biomass and soil over decades to millennia, that are vulnerable to release into the atmosphere by human activities. If released, this carbon will not be restored (or naturally re-sequestered) by 2050, the point at which the world must reach net-zero emissions to avoid the worst consequences of climate change.[3] Our team has identified ten distinct high-carbon areas (HCAs) in the United States for further research and engagement. Based on levels of threat, vulnerability, and the levels of co-benefits that would be protected in these landscapes, we have determined three of the ten areas to be most critical to target protection activities—Appalachia, the Pacific Northwest, and the Northern Rockies.

The Northern Rockies represents an area of particular land connectivity, biodiversity, and other ecosystem values. Conferring additional protections, or revising management strategies, on the basis of carbon storage helps strengthen existing intact-ecosystem connections between Montana, Idaho, and Washington; helps avoid carbon loss driven by catastrophic wildfire; and enhances protection of air, water, and recreational quality.

Our research has led us to conclude that the greatest potential for protecting IRC in the Northern Rockies is to encourage existing networks and organizations that work on landscape connectivity, biodiversity, and conservation to consider using IRC content to increase land protection. This memo provides a regional assessment of the IRC in this HCA, the threats it faces, co-benefit concerns, a policy overview of the area, and an explicit call to action as it relates to IRC protections.

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Regional IRC assessment

The Northern Rockies HCA, which spans northwestern Montana, northern-to-central Idaho, and northeastern Washington, contains a significant store of IRC. The total amount of carbon it stores, 450 megatonnes, is held almost exclusively in the region's millions of trees (Figure One, Figure Five). This represents approximately seven percent of the total IRC in the United States.

The carbon of the Northern Rockies faces threats from invasive species, drought, and wildfire. Wildfire, especially catastrophic wildfire fueled by years of fire suppression, increased fuel loads, and reduced average annual snowpack, results in near-instantaneous carbon release from burning trees, accelerating the problem of climate change.

While the area does face climate-related threats, management action such as restoration—including tree planting—and fire mitigation efforts that prioritize long-term forest health and low-intensity fires can help to keep carbon safely stored in trees and other biomass.

The United States Forest Service (USFS) manages 66% of the IRC in this region, making that agency the primary party responsible for decisions that could affect stores of IRC. However, 22.9% of the region's IRC is managed by private entities—such as homeowners in the wildland-urban interface, private timber interests, and NGOs with land trust holdings—and much of this land directly abuts federal and state IRC holdings (see figure two). While beyond the scope and focus of this memo, additional viable pathways for increased protection of IRC could include working with homeowners, organizations, and trusts to protect the IRC in these privately held lands to maintain the health and connectivity of all lands in this HCA.

To understand the overall vulnerability of these lands to conversion and carbon release, our team evaluated the HCA's GAP Status. GAP Status Codes are used to describe the "measure of management intent to preserve biodiversity" of land areas.[4] GAP Status 1 and 2 indicate lands that are permanently protected from conversion and have mandated natural land management plans in operation. GAP status 3 lands have a degree of permanent protection from land conversion, but are subject to extractive use (like timber harvesting, ORV usage, or mining). GAP status 4 areas have no known permanent protections against land conversion.

[4]https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/atoms/files/GAP%20Status%20Code%20Assignment_2021.pdf

Seven-and-a-half percent of the IRC in this region is GAP 1 status, 2.4% is GAP 2, 62.4% is GAP 3, and 27.5% is GAP 4 (figure three). GAP status 3 and 4—the majority of the IRC's total acreage—are prime candidates for protection based on carbon storage while simultaneously conferring protections on land connectivity, biodiversity, and overall ecosystem health.

IRC & Co-Benefits

The density of IRC in the USFS-managed forests of the Northern Rockies directly correlates with many other vital ecosystem services. Lands with the highest amount of IRC in this region overlap significantly with lands that are rich in ecological integrity, connectivity, ecosystem representation priority, and biodiversity according to a 2017 study by Belote et al that evaluated the potential for increasing land protections based on co-benefits.[5] This area's multitude of co-benefits—also including recreation, air and water quality, and critical habitat—mean protecting IRC has significant, positive downstream impacts on other important measurements of a healthy ecosystem.

Because of this overlap, prioritization of IRC in land management will benefit other conservation goals. As we face a warming climate, conservation actions that prioritize IRC also help in conserving the coniferous forests ecosystems that provide crucial wildlife corridors, air and water purification, essential habitat for non-human biodiversity, and billions of annual dollars in economic value via recreation.[6] Considering and prioritizing the protection of IRC in the management of National Forests, creation of National Forest Plans, and implementation of those plans, will yield co-benefits, all of which are vital in the fight against climate change.

Threats to IRC in the Northern Rockies

While other HCAs throughout the US face higher threats from development and other human-centric activities, climate change, as well as numerous associated impacts like catastrophic wildfire and drought, pose threats to the landscape of the Northern Rockies and the vast amounts of carbon it stores in biomass.

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[5] Belote, R. Travis, et al. "Wild, Connected, and Diverse: Building a More Resilient System of Protected Areas." Ecological Applications, vol. 27, no. 4, June 2017, pp. 1050–56. DOI.org (Crossref), https://doi.org/10.1002/eap.1527.

[6] https://lmi.mt.gov/_docs/Publications/EAG-Articles/EAG-1222_Final.pdf

While the USFS does not specifically manage forests for the purposes of carbon sequestration, they do manage with wildfire in mind. Much of that management is a reactive response aimed at addressing the consequences of harmful fire suppression practices of the past. The Rocky Mountain Research Station has conducted studies that quantify the effects of fire suppression regimes and has found that wildfires in the 1990s and 2000s would have been significantly less intense, widespread, and difficult to manage with the use of proactive fire management techniques.[7]

Catastrophic wildfires in this HCA—apart from direct harm to humans and property—result in loss of biodiversity, harm to waterways, and soil sterilization. Damaging wildfires also create visual disturbances that may harm recreational use. Fire management is explicitly related to stored carbon, so land-use choices that affect fire intensity are also choices that affect irrecoverable carbon.

New Resources for Expanded Protection

Through the Bipartisan Infrastructure Law (BIL), the USFS has new funding and new incentive to look closely at lands in this primarily USFS-managed area.

The BIL allocated $5.5 billion in funding to USFS, $3 billion of which is specifically directed towards mitigating wildland fire risk and restoring affected ecosystems. These activities go beyond historic fire suppression measures and dovetail with the USFS's stated intent to update their wildland fire activities to include prescribed burns that reduce fuel loads.[8]

> "Of the $5.5 billion, about $3 billion will be invested over five years to reduce the risk of wildland fire and restore ecosystems. These investments will support our 10-year strategy for reducing wildfire risk by treating the right landscapes at the scale needed to sustain and restore healthy, resilient fire-adapted forests." - USDA

The BIL also removed the $30 million cap on the Reforestation Trust Fund, which opens up even more funding for land connectivity (decommissioning legacy roads), biodiversity

[7] https://www.fs.usda.gov/rmrs/research-topics/fire
[8] Bipartisan Infrastructure Law. https://www.usda.gov/infrastructure.

concerns (restoring fish passages), and recovering from wildfire (tree replanting). Montana alone is set to receive $23 million over the next five years to protect against wildfire.

The Inflation Reduction Act of 2022[9] allocates another $5 billion dollars to the USFS for fuels and forest health treatment, with $2.15 billion available to "improve forest conditions on national forests." $1.8 billion of that is explicitly available to conduct fuels reduction and wildfire resilience work on National Forest System lands.

While explicitly connected to wildfire prevention and reforestation, this funding can also be viewed as an investment in keeping irrecoverable carbon locked in trees and biomass—but only if the funds are directed at these specific high-carbon areas. National Forest lands in this area overlap but are not precisely overlaid with high-IRC areas (figure four). Directing funding and protection efforts to areas under National Forest management that also contain high levels of IRC will result in a reduction in irrecoverable carbon release from these areas.

Organizations can now take advantage of this increased momentum to advocate for carbon sequestration, which will also benefit a host of other ecosystem services relevant to organizational priorities. This funding will be best spent if carbon is understood as an inherent value of the forest systems that may be lost because of extreme wildfire.

Opportunities to Leverage Carbon Protection for Additional Landscape and Forest Protection

As is well known, there is significant interest at the federal level to confer protection on lands using novel frameworks, such as carbon storage and sequestration. For example, H.R. 565, the Land Restoration and Resilience Act of 2023, was introduced by Joe Neguse [D-CO-2] and offers funding for organizations to "protect and enhance the biodiversity of wildlife populations across restoration and resilience lands." Resilience lands are defined as numerous "important natural areas" across the US, including public, private, and Indigenous lands.[10] The intentional vagueness of this language offers a viable entrypoint to advocate for land conservation on several different grounds, including carbon sequestration and storage.

[9] Inflation Reduction Act. https://www.usda.gov/ira.
[10] https://www.congress.gov/bill/118th-congress/house-bill/565?s=1&r=13

Furthermore, there exists a financial incentive to designate areas "protected" based on stored carbon alone. Citing research by Julie Loisel and Jayme Walenta in *Nature Ecology and Evolution*:[11]

> "In this case, additionality is established by comparing the carbon inventory of an intact carbon-rich site against the average carbon stock of a similar, but exploited, carbon-rich ecosystem, documenting avoided emission loss. Crucially, these 'avoided emissions' can be quantified using existing biophysical measurements (or models), transferred into CO2 equivalent, and linked to climate change offsets. Financial and/or other incentives could be created to safeguard that carbon and possibly serve as an 'avoided emissions class' tracked through carbon accounting schemes, such as scope 3 financed emissions."

While unregulated carbon markets can provide relatively inexpensive offset opportunities for organizations seeking to reduce their emissions impact, there is significant evidence suggesting carbon offsets—especially those that support projects that would have proceeded without organizational support—are grossly ineffective.[12] However, in 2022, the Commodity Futures Trading Commission (CFTC) convened a roundtable to initiate regulating and monitoring carbon offsets and their derivatives. This important move, as well as corporate interest in offsets as assistive in reaching carbon-reduction goals, can help legitimize the carbon offset market. When regulated, carbon offsets can be an effective, fiscally attractive tool that helps corporations achieve their carbon footprint goals and keeps carbon in trees, soils, and other

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[11] Loisel, Julie, and Jayme Walenta. "Carbon Parks Could Secure Essential Ecosystems for Climate Stabilization." Nature Ecology & Evolution, vol. 6, no. 5, May 2022, pp. 486–88. www.nature.com, https://doi.org/10.1038/s41559-022-01695-1.

[12] The CFTC Should Raise Standards and Mitigate Fraud in the Carbon Offsets Market. (2023, January 24). Center for American Progress. https://www.americanprogress.org/article/the-cftc-should-raise-standards-and-mitigate-fraud-in-the-carbon-offsets-market/

biomass.[13] As carbon markets inevitably expand to other states in coming years, IRC can be incorporated into market considerations, at great ecological benefit to the forests of the Northern Rockies.

Additionally, we can look to Tribal land managers for other ways to conceptualize carbon as a focused and integral part of healthy forest management. The Confederated Salish & Kootenai tribes of Montana use the following language in their definition of ecosystem management within their forest management plans:[14]

> "The integrated use of ecological knowledge at various scales to produce desired resource values, products, services, and conditions in ways that also sustain diversity and productivity of ecosystems. This approach blends physical, biological, cultural, and social needs."

This language, and other similar language in Tribal forest management documents across the country, can be read to directly incorporate and prioritize carbon in forest management.

In short, organizations and advocates seeking to increase land protections on the basis of ecosystem services could use the concepts of "carbon parks," carbon markets, and novel interpretation of Tribal management practices to achieve these objectives while simultaneously protecting IRC from release.

Call to action

This memo has included a regional assessment of threats and opportunities in this HCA for increasing protection of lands by considering carbon storage, looking especially at irrecoverable carbon content to inform decision-making. The following are top-line recommendations for organizations seeking to increase land protections on this basis:

- Advocate for the FS to increase the priority of carbon sequestration and carbon storage as they make decisions about management of the Northern Rockies Forests and Lands.

[13] Ibid
[14] Tribal Forestry. (2019). Csktribes.org. https://csktribes.org/natural-resources/tribal-forestry

- Press the FS, BLM, FWS and USGS to increase data collection and integration of data systems to incorporate carbon mapping into GIS systems used for forest planning, critical habitat designation, and evaluation of environmental impacts.
- Add protection of IRC to other arguments for reforestation.
- Include consideration of carbon protection in the priority systems used for investment of the BIL and IRA funding.
- Use emerging incentives and opportunities to sequester carbon and mitigate climate change as additional support for landscape-scale protection.

Conclusions

For all these reasons, we encourage you to consider carbon and IRC in your organizational goals, community engagement, and strategic planning. Please call on the Forest Service to increase their consideration of carbon in their planning and management decisions, explicitly value carbon in their cost-benefit analyses, and center their fuels reduction efforts on conserving high-value IRC in specific zones within this HCA (Figure Four). The forests of the Northern Rockies are vital in their wide assortment of ecosystem services, essential habitat for a multitude of important species, and cultural value for Indigenous and non-Indigenous communities. Carbon storage is yet another incredibly important reason to conserve these landscapes, and we believe that actively encouraging the USFS to prioritize irrecoverable carbon consideration in their forest planning processes, wildfire mitigation systems, and land management decisions, can help your organization achieve its broader conservation goals.

Appendix

Figure One: Total IRC in HCA

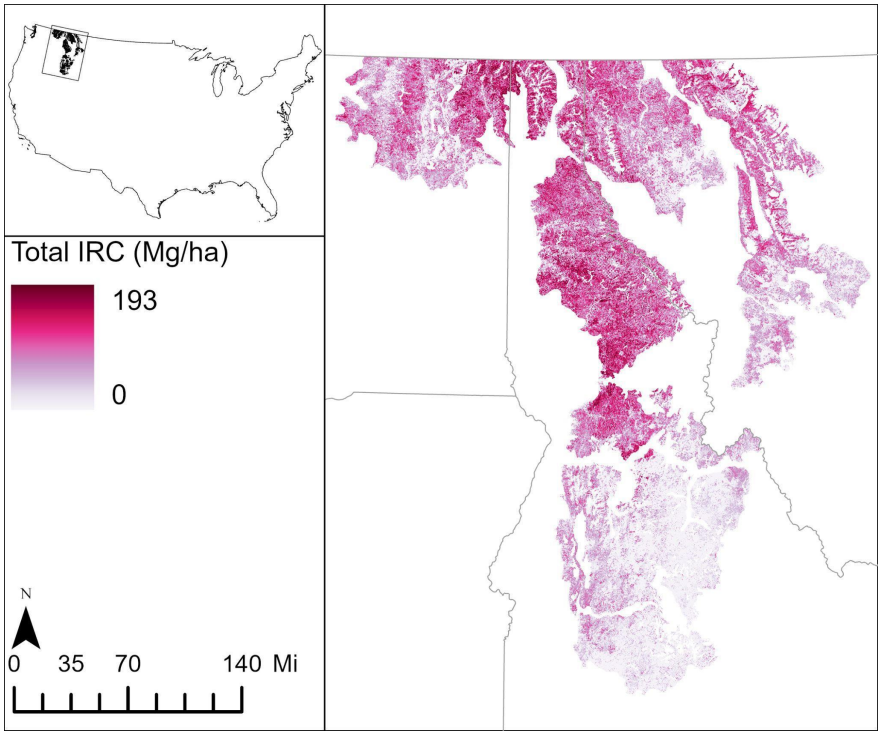
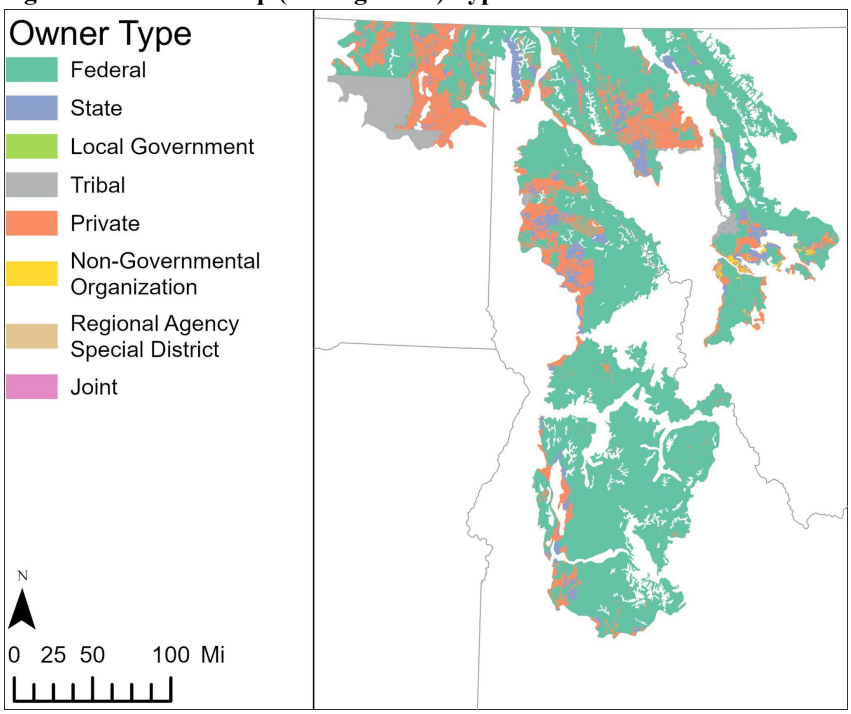


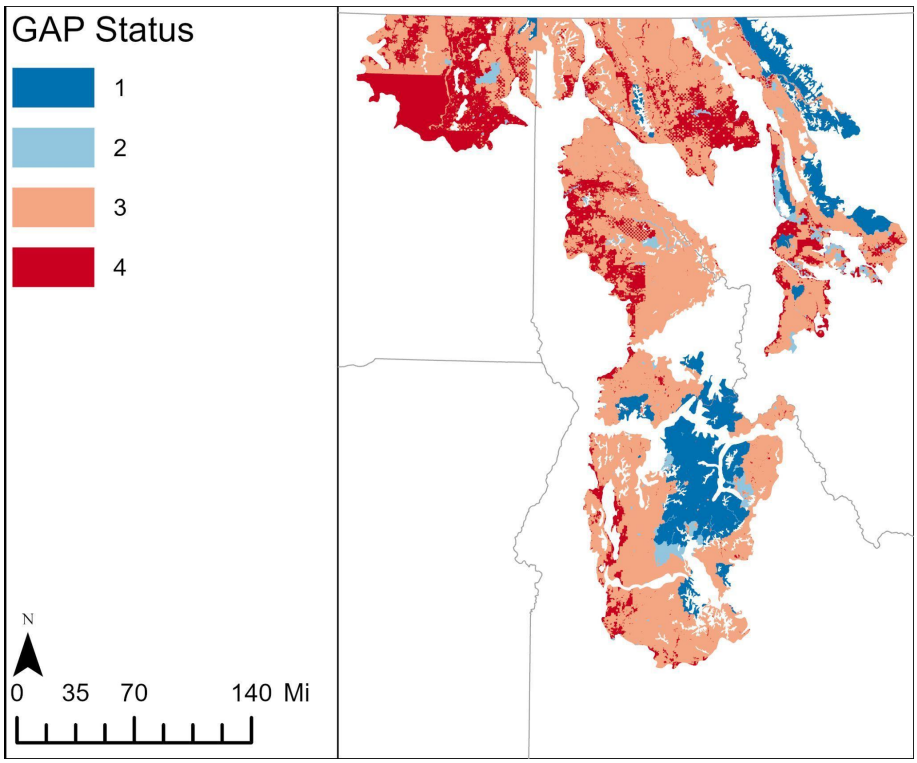
Figure Two: Ownership (Management) Type



Based on USGS PADUS data and metadata, we used the data category "Manager Type" as a proxy for and the most accurate representation of land ownership. As stated in the metadata for the dataset, "Use the 'Manager Type' field for the best general depiction of Federal lands…as several ownership related data gaps

occur…" We tested use of other ownership data and found that using this assumption – manager type for ownership – resulted in the most accurate representation of land ownership.[15]

Figure Three: GAP Status of HCA



GAP Status describes a land area's protection status with GAP 1 as the most protected against conversion and GAP 4 the least. The majority of the IRC in this HCA occurs in GAP Status 3 lands, which have some degree of permanent protections but are subject to extractive use like ORV, timber harvesting, or mining. There are no known protections in GAP Status 4 lands.

[15] https://www.usgs.gov/programs/gap-analysis-project/pad-us-data-manual

Figure Four: IRC overlap with National Forest System Lands

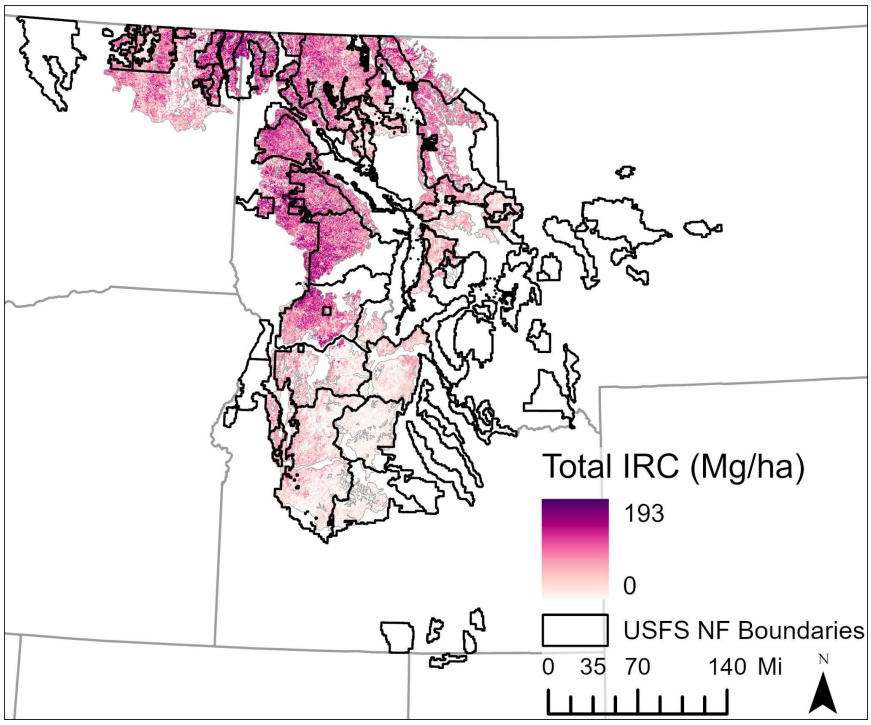


Figure Five: Ecosystem type in HCA