LIBERIA
MAPPING NATURAL CAPITAL

JULY 2017

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CONSERVATION INTERNATIONAL

NATURAL CAPITAL — OUR ECOSYSTEMS, BIODIVERSITY, AND NATURAL RESOURCES — UNDERPINS ECONOMIES, SOCIETIES AND INDIVIDUAL WELL-BEING.

- **ELLEN JOHNSON SIRLEAF, PRESIDENT OF LIBERIA**

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Acknowledgements:

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INTRODUCTION

Nature is fundamental to achieving social and economic development.

The importance of *natural capital*, the biodiversity and ecosystems that underpin human well-being and economic activity, has been recognized at national and international levels. Integrating natural capital into sustainable economic growth and production is at the core of national commitments to the Gaborone Declaration on Sustainability in Africa and the United Nations Sustainable Development Goals. Meeting these commitments requires countries to develop a fundamental baseline that defines the spatial extent, condition, and benefits provided by natural capital.

In Liberia, examples of natural capital include mangroves that protect vulnerable coastal populations; fisheries that provide sources of food and income; rivers and wetlands that provide drinking water and hydroelectricity; and forests that contain globally significant carbon stocks. In 2016, scientists from Conservation International collaborated with the Liberia Environmental Protection Agency (EPA) to conduct a pilot project to begin to map and account for Liberia's natural capital, in order to better understand and integrate the role of natural capital as Liberia defines and implements a pathway to achieving sustainable growth and production in the future.

LIBERIA

The Republic of Liberia is situated on the west coast of Africa, encompassing a land area of approximately 111,370 km^2 (about 43,506 square miles). It has a population of approximately 4.5 million, made up of more than 16 major ethnic groups, the largest ones include the Kpelle, Kru, Bassa, Krahn, Grebo, and Lorma. Smaller ethnic groups include Belle, Sapo, Mende, Gbandi, Vai, Mandingo, Gio, Mano, Kissi and Gola. These ethnic groups constitute 97% of the population. More than 70% of the population is rural and depends principally on biological resources for livelihoods.

The country falls within the Guinean Forests of West Africa Biodiversity Hotspot, which is a global priority for primate conservation due to high levels of endemism (92% of the hotspot's 30 primate species are endemic) and high level of threat. Average annual rainfall along the coastal belt is over 4,000 mm and declines to 1,300 mm at the forest-savanna boundary in the north.

Natural ecosystems in Liberia provide critically important benefits to its people, including providing sources of food, energy, water, and building materials, as well as cultural identity. Natural ecosystems provide services that benefit agriculture in the form of soil quality, pest regulation, and local climate regulation. Coastal ecosystems such as mangroves protect vulnerable coastal populations and provide fish and other products which are critical to Liberia's food security. Forests provide timber, bushmeat, charcoal, firewood, and other products that support 70% of Liberia's rural population. Rivers provide sources of drinking water and power hydroelectric dams. Forests store and sequester carbon, mitigating global climate change. Lastly, natural ecosystems provide important cultural services to Liberia's people, including cultural identity, recreation, and tourism.

MAPPING NATURAL CAPITAL

Mapping Natural Capital provides baseline information on the extent, condition, and benefits that natural ecosystems provide to people and the economy.

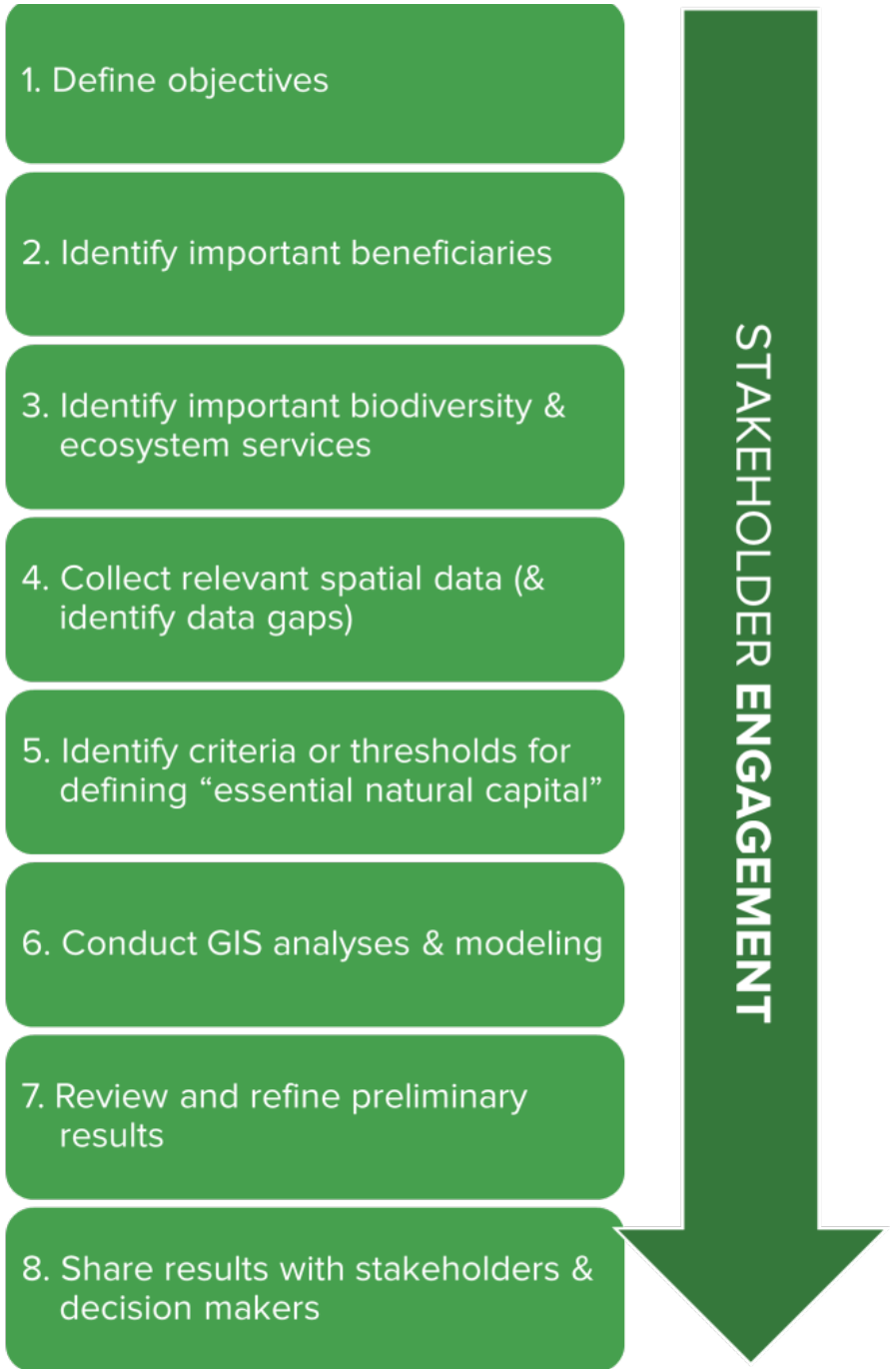
Conservation International has developed a framework for mapping a country's essential natural capital, outlined on the right.

In this project, we developed maps of natural capital for the following values: biodiversity, forest carbon, bushmeat and non-timber forest products, freshwater ecosystem services, and coastal protection. We brought together existing data from global and national sources (a complete list can be found at the end of this document), with spatial analyses using geographic information systems (GIS) and ecosystem services modeling using tools such as WaterWorld and InVEST.

This critical information can provide a first-cut assessment enabling Liberia to make important natural resource decisions as it develops plans for achieving sustainable development targets. We also built an ecosystem account for Liberia's timber sector, to show the linkages between Liberia's natural capital (forests) and its national economy. An ecosystem accounting approach can dramatically strengthen planning, policy, and investor confidence through the inclusion of biodiversity and ecosystem services in a given country's statistical framework. In the future, our goal is to ensure that efforts to integrate nature into decision-making – through Natural Capital Accounting – revolutionize development planning and policy-making, sustainable economic growth, and subsequent reporting on for the UN SDGs.

For more information about the methods, data sources, and results, please see the accompanying technical report:

Conservation International. 2017. Natural Capital Mapping and Accounting in Liberia: Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development. Arlington, VA. 97 pp.



Liberia


Voinjama
Lofa
GUINEA
SIERRA LEONE
Gbarpolu
Ganta
Cape Mount
LIBERIA
Gbarnga
Bong
Nimba
COTE D'IVOIRE
Robertsport
Bomi
Margibi
Kakata
Montserrado
City
Monrovia
Bassa
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Sinoe
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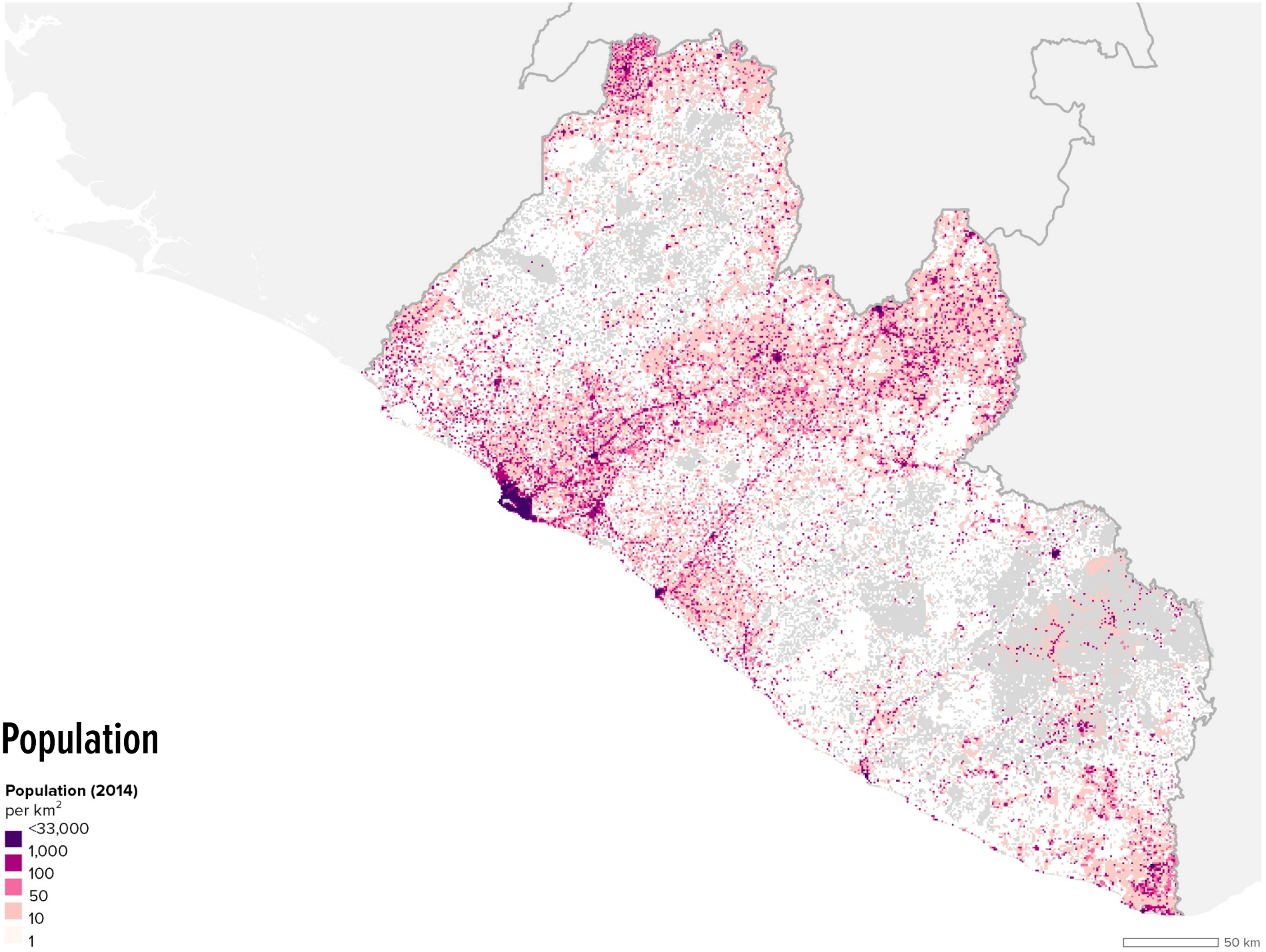
Grand Kru
Maryland
Harper City
50 km



Bright EA, Coleman PR, Rose AN, Urban ML. 2012. LandScan 2011. Oak Ridge National Laboratory. Available from http://web.ornl.gov/sci/landscan/

LAND COVER & CHANGE

MAX WRIGHT

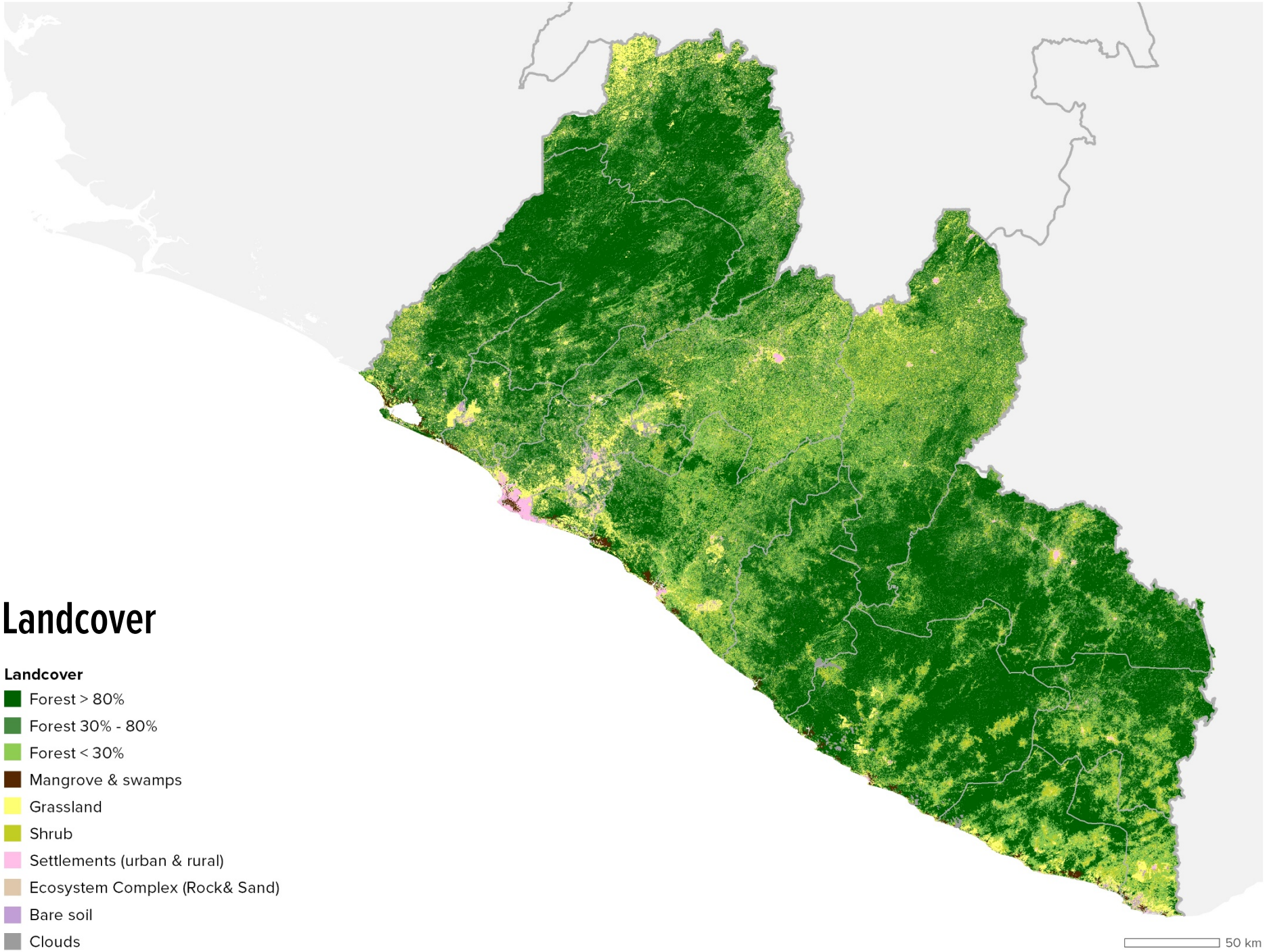
LAND COVER & CHANGE

Liberia is dominated by forests, including lowland forests (comprised of wet evergreen forests in areas with rainfall above 2,000 mm) and moist semi−deciduous forests (in areas with rainfall between 1,600 mm and 2,000 mm.) Other ecosystems within Liberia include mangroves, shrublands, and grasslands. Continuous high density forests once dominated the whole territory of Liberia. However, in recent times, land development, timber extraction and introduction of rubber plantations have opened areas of high density forests and resulted in the expansion of agriculture and mining. As a result, man-made savanna is spreading along the coast and extending inland, while the same can be observed along the northern Liberian border. This area is now supporting a diverse mix of vegetation ranging from low bush, patches of high forest, gallery forests near rivers, grass dominated, thorny shrubs, and cultivated land.

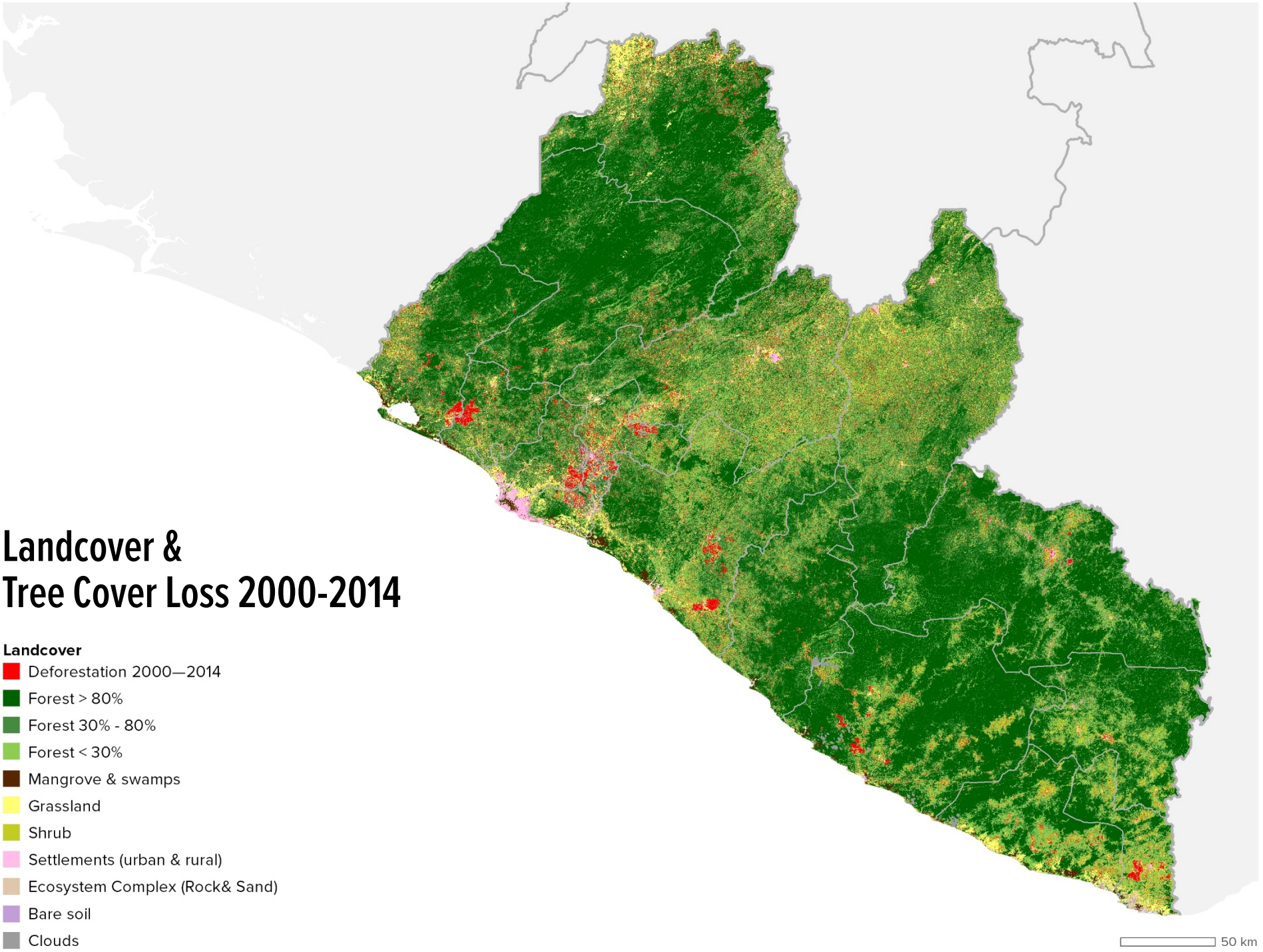
For our analyses, we used a 2015 national land cover product (produced by JV Metria/Geoville) and combined it with global data on tree cover loss from 2000-2014 (Hansen et al. 2013). We also analyzed tree cover loss within specific land use types, such as concession areas.

The annual deforestation (tree cover loss) rate in Liberia is approximately 0.31%, however this number may vary significantly depending on the forest definition used, and whether plantation forests are included. Large areas of tree cover loss along Liberia's coast are a result of recent clearing for oil palm. The band of tree cover loss in the center of the country, extending from the coast outside Monrovia to the middle of the country, is driven by rubber plantations. Finally, there are small (<1 ha) patches of tree cover loss scattered through the central corridor of the country. This loss is likely a result of human pressures, such as small scale agriculture, charcoal production, and local timber harvesting.

JV Metria/Geoville. 2015. Liberia Land Cover and Forest Mapping 2015. JV Metria/Geoville and Forestry Development Authority, Monrovia, Liberia.
Hansen MC et al. 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342:850–853.



JV Metria/Geoville. 2015. Liberia Land Cover and Forest Mapping 2015. JV Metria/Geoville and Forestry Development Authority, Monrovia, Liberia.



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Hansen MC et al. 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342:850–853.

LAND COVER & CHANGE

Table 1. Tree cover change by land-use designation

	Tree cover 2000 (ha)	Proportion of tree cover 2000	Tree cover 2015 (ha)	Proportion of tree cover 2015	Tree cover loss 2000-2014 (ha)	Proportion of loss 2000-2014	Tree cover loss rate % yr-1
Liberia total	8,504,508.96	-	8,141,749.38	-	362,759.58	-	0.30%
Proposed protected area	867,034.62	10.19%	861,213.06	10.58%	5,821.56	1.60%	0.05%
Designated protected area	325,240.11	3.82%	322,043.94	3.96%	3,196.17	0.88%	0.07%
Ratified timber concession	984,586.77	11.58%	978,402.24	12.02%	6,184.53	1.70%	0.04%
Proposed timber concession	1,227,087.81	14.43%	1,216,625.40	14.94%	10,462.41	2.88%	0.06%
Oil Palm plantations	614,070.45	7.22%	560,822.13	6.89%	53,248.32	14.68%	0.62%
Rubber plantations	60,521.49	0.71%	40,352.31	0.50%	20,169.18	5.56%	2.38%

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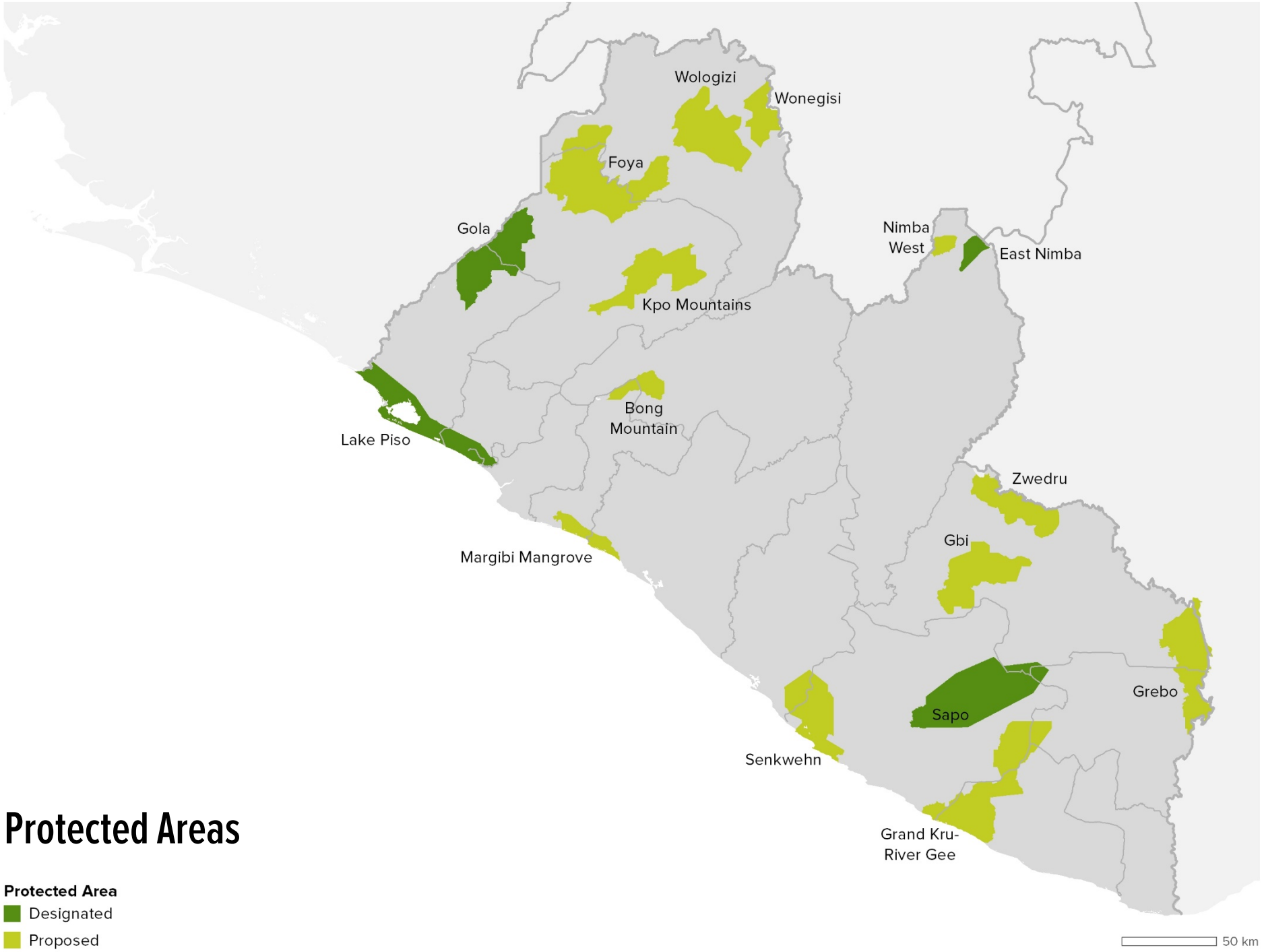
PROTECTED AREAS

As of 2016, Liberia has four designated protected areas (Sapo National Park, East Nimba National Park, Lake Piso Multiple Use Reserve, and the newly designated Gola Forest National Park), encompassing approximately 362,000 ha, and twelve proposed protected areas (~910,000 ha). Altogether, these areas comprise approximately 1,272,000 ha.

In 2003, the Liberian Forestry Development Authority (FDA) signed the Act for the Establishment of a Protected Forest Areas Network, which committed the government to establish, “a biologically representative network of protected areas covering at least 30% of the existing forest area.”

For our analyses, we combined data on designated and proposed protected areas from the World Database on Protected Areas, updated to reflect two recently designated areas (Lake Piso and Gola Forest), with national land cover data from 2015 (JV Metria/ Geoville and FDA.)

Currently, 3.8% of Liberia’s land area falls within designated protected areas, and if proposed protected areas were all formally designated, this number would rise to 13.2%. Designated protected areas currently encompass 5.6% of Liberia’s densest forests (those with canopy cover of >80%), 2.7% of Liberia’s moderately dense forests (30-80% canopy cover), and 0.6% of more open canopy forests (<30%). Proposed protected areas, if designated, would result in protection of a total of 20.5% of Liberia’s densest forests, 9.2% of its moderately dense forests, and 4.8% of its open forests. For mangroves, 22.3% of mangroves currently fall within designated protected areas, but this number would rise to 45.6% of mangroves if proposed protected areas were formally designated.

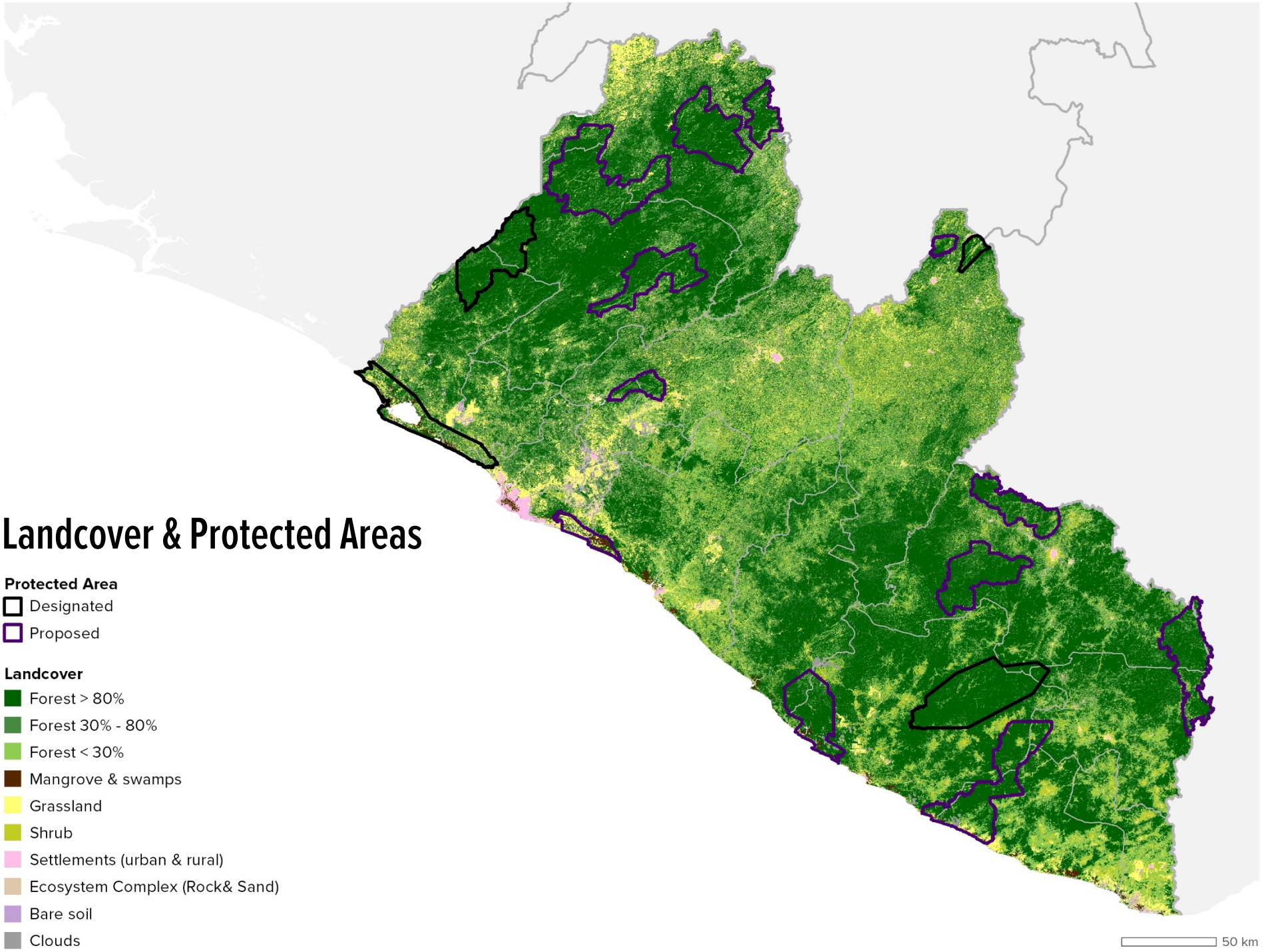


Protected Areas

Protected Area

- Designated
- Proposed

IUCN and UNEP-WCMC (2016), The World Database on Protected Areas (WDPA) Cambridge, UK: UNEP-WCMC. Available at: www.protectedplanet.net



JV Metria/Geoville. 2015. Liberia Land Cover and Forest Mapping 2015. JV Metria/Geoville and Forestry Development Authority, Monrovia, Liberia.
IUCN and UNEP-WCMC (2016), The World Database on Protected Areas (WDPA) Cambridge, UK: UNEP-WCMC. Available at: www.protectedplanet.net.

LANDCOVER & PROTECTED AREAS

Table 2. Area in different landcover types, and within designated and proposed protected areas (PAs). Data source: JV/Metria Geoville and FDA 2016.

Landcover	Area (ha)	Percent	Area in Designated PAs (ha)	Percent in Designated PAs	Area in Proposed PAs (ha)	Percent in Proposed PAs	Area in Designated & Proposed PAs (ha)	Percent in Designated & Proposed PAs
Forest >80%	4,364,751	45.37%	246,190	5.6%	648,289	14.9%	894,479	20.5%
Forest 30-80%	2,167,707	22.53%	59,081	2.7%	139,961	6.5%	199,042	9.2%
Forest <30%	1,523,056	15.83%	8,538	0.6%	64,380	4.2%	72,918	4.8%
Mangrove	37,142	0.39%	8,268	22.3%	8,656	23.3%	16,924	45.6%
Settlements	44,604	0.46%	254	0.6%	211	0.5%	466	1.0%
Water	60,529	0.63%	15,591	25.8%	4,749	7.8%	20,340	33.6%
Grassland	626,038	6.51%	16,484	2.6%	19,551	3.1%	36,035	5.8%
Shrub	606,919	6.31%	5,666	0.9%	13,936	2.3%	19,601	3.2%
Bare soil	173,917	1.81%	1,738	1.0%	3,831	2.2%	5,568	3.2%
Ecosystem complex (rock and sand)	2,252	0.02%	446	19.8%	386	17.1%	832	36.9%
(Clouds)	14,391	0.15%	0	0.0%	5,553	38.6%	5,553	38.6%
TOTAL	**9,621,306**	**100%**	**362,256**	**3.8%**	**909,503**	**9.5%**	**1,271,759**	**13.2%**

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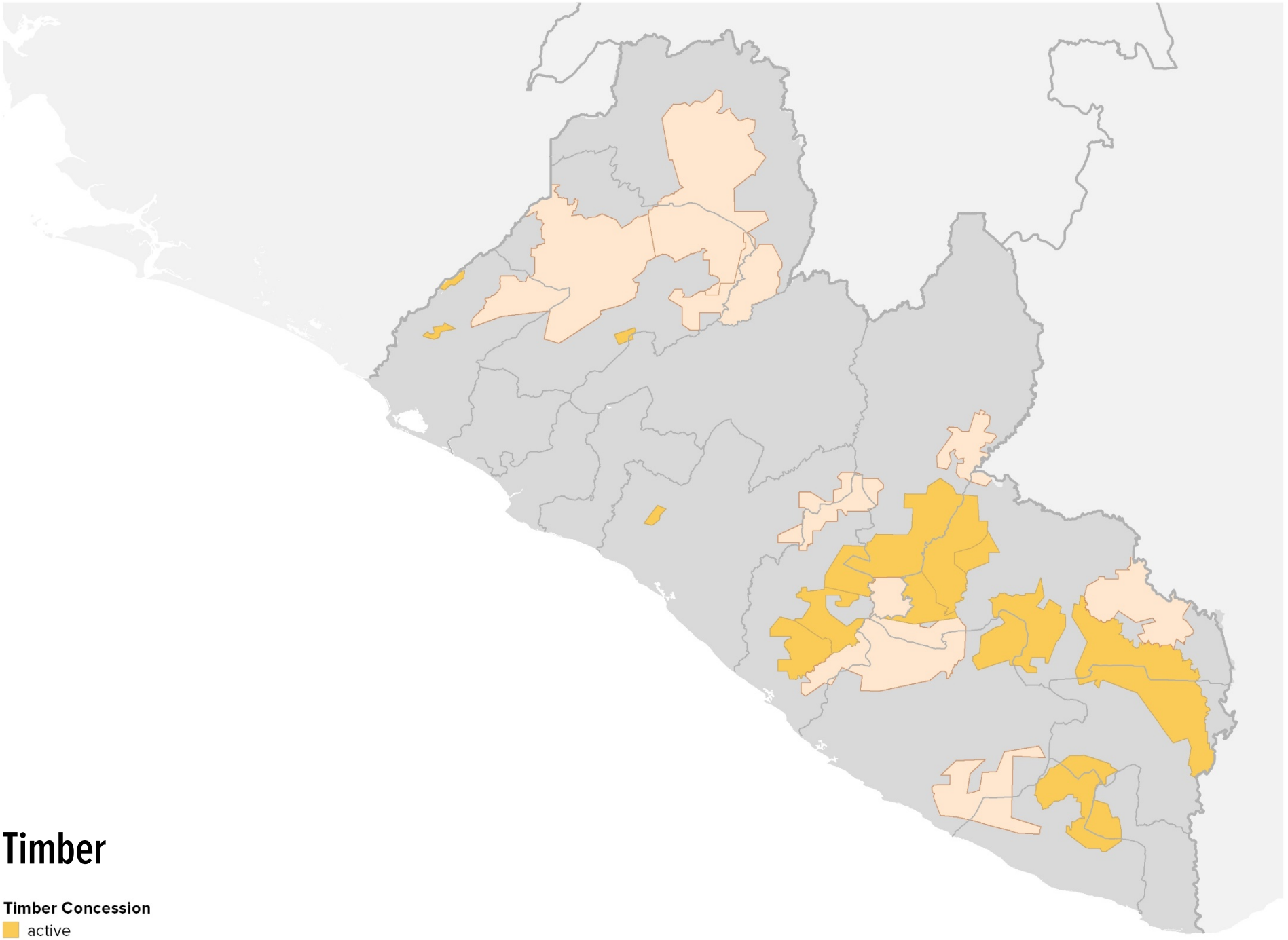
FORESTS & TIMBER

Forests in Liberia cover about 4.3 million hectares, representing 45% of the country's land area. Forests make a large contribution to the economy by employing a large workforce and providing as much as 50% of export revenues. In this pilot study, we developed components of a timber account, as a basis for the future development of more comprehensive Forest Accounts as well as Ecosystem Accounts in Liberia.

For this analysis, we used data on the location of timber concessions, the location and quantity of timber harvests in those concessions, the quantity of timber harvested through chain-saw logging, and financial data. Most data were provided by the government of Liberia (Forestry Development Authority); the financial data were verified and adjusted using alternative data sources.

In the year 2015 the total economic contribution of forests to the timber industry was USD 221 million, of which the bulk was contributed by commercial concessions (USD 212 million). In 2015, Liberia's GDP was estimated at USD 2.05 billion. Therefore, roughly 11% of GDP can be attributed to the timber industry. However, this is an under-estimate of the total contribution of the forestry sector to the country's economy, as data were not available for timber harvested for local use. Moreover, valuable non-timber forest products generated by forests were also not accounted for.

It is also important to note that commercial timber concessions overlap with the most intact and biodiversity-rich natural forests in Liberia. While the timber industry makes a substantial economic contribution to Liberia's economy, development in this sector most be done sustainably. More comprehensive accounting of Liberia's forest products would help ensure that the trade-offs between development and conservation are minimized, and that the goods and services provided by forests and other ecosystems are accounted for in policy and decision-making processes.



LISGIS (Liberia Institute of Statistics and Geo-Information Services.)

FORESTS & TIMBER

Table 3. Economic contribution of timber industry to different sectors

Sector	2015 total economic contribution (USD)		
	Chainsaw	Concession	Total
Government	484,874	20,983,610	21,468,484
Businesses	4,030,320	96,300,086	100,330,406
Households	3,068,868	65,959,244	69,028,112
Rest of world	1,283,844	28,954,712	30,238,556
Total	**8,867,906**	**212,197,651**	**221,065,558**

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INSIGHT

ROUGHLY 11% OF LIBERIA'S GDP CAN BE ATTRIBUTED TO THE TIMBER INDUSTRY.

HOWEVER, COMMERCIAL TIMBER CONCESSIONS OVERLAP WITH THE MOST INTACT AND BIODIVERSITY-RICH NATURAL FORESTS IN LIBERIA


PALM OIL, RUBBER & MINING
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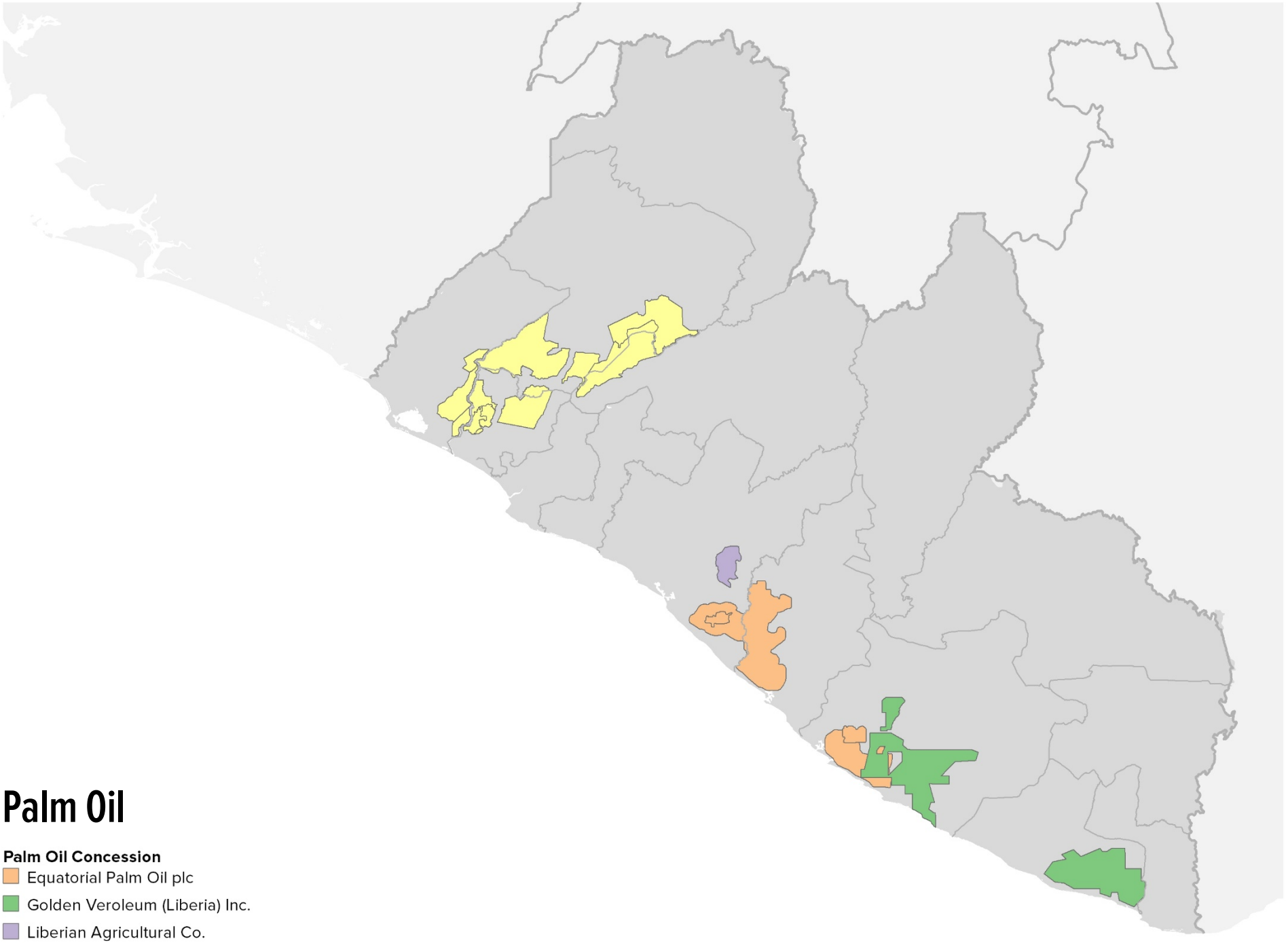

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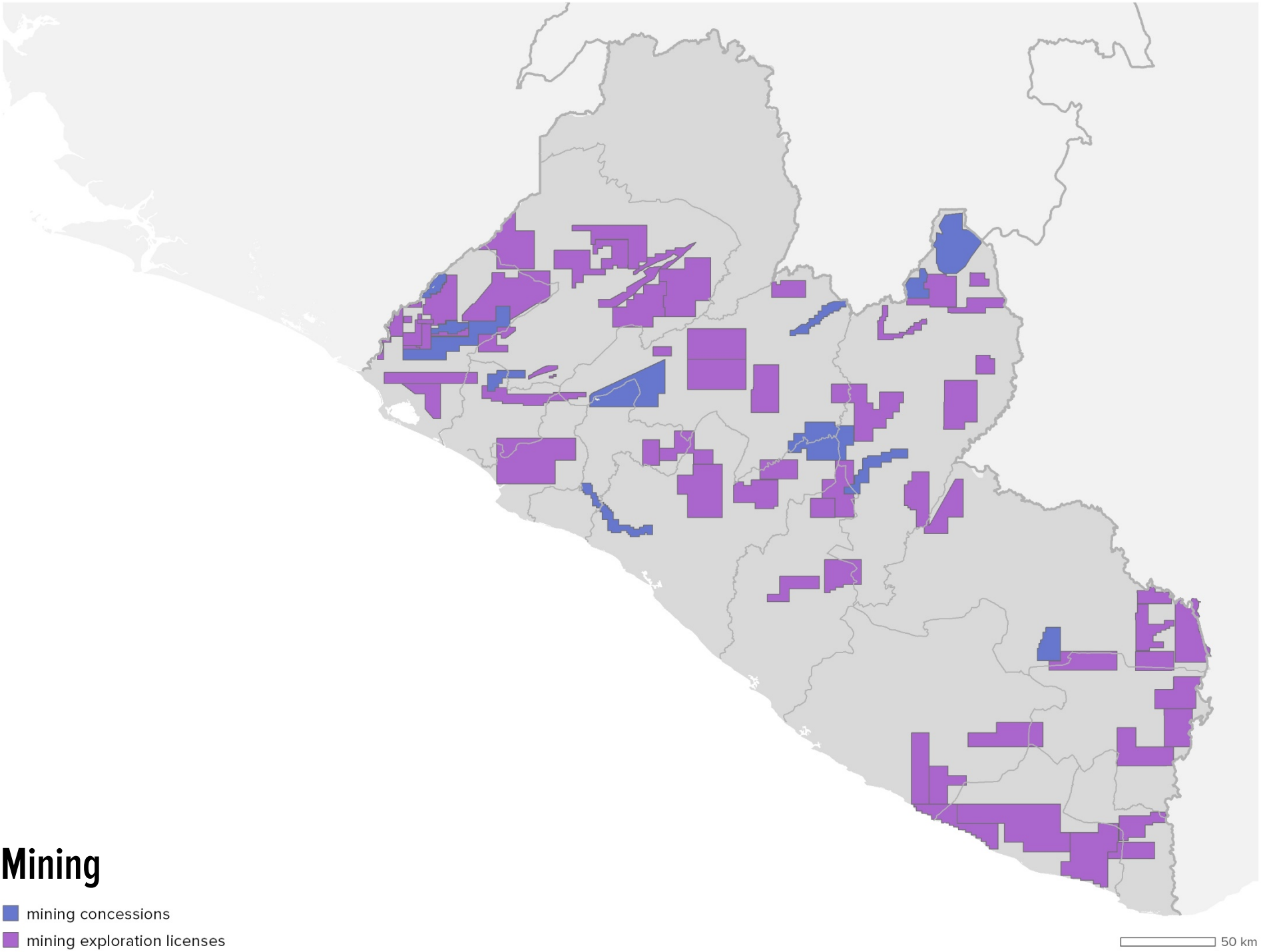


LISGIS (Liberia Institute of Statistics and Geo-Information Services.)

BIODIVERSITY

TROND LARSEN AND RACHEL NEUGARTEN

CONTRIBUTIONS FROM JESSICA JUNKER

BIODIVERSITY

We assessed existing datasets on biodiversity in Liberia for their level of completeness and currency. We opted to use a recent dataset based on transects and surveys of chimpanzees, IUCN Red Listed large mammals, and trees conducted systematically throughout the country (Tweh et al. 2014).

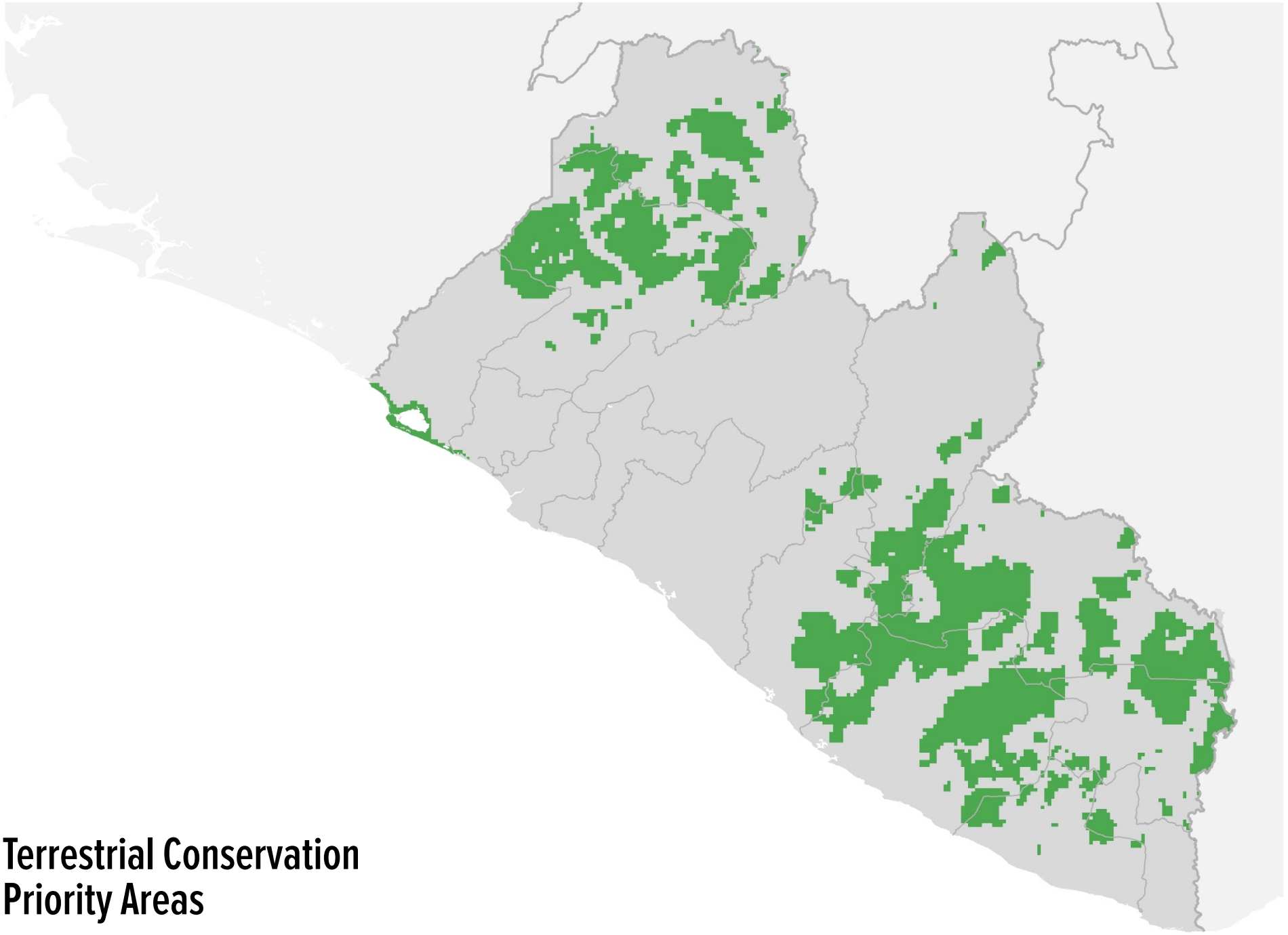
Ninety-two conservation priority areas were identified in Liberia based on this nationally representative dataset (Junker et al. 2015). The authors used a tool called Marxan to identify overall conservation priority areas for the 30% of all Liberia's forests that would preserve the most important biodiversity.

Only around 9% of these conservation priority areas are contained within designated protected areas. If proposed protected areas were designated, 33% of these conservation priority areas would be preserved. Due to the large size of some of the priority areas, protecting even 6 out of 92 priority areas would help to ensure the long-term viability of Liberia's chimpanzee population as well as a diversity of other large mammals and tree species.

Very few of the conservation priority areas fall within concessions for mining, oil palm or rubber, but there is significant overlap with timber concessions. All future concessions will require careful planning and management to ensure biodiversity is not compromised. Additional research on Liberia's coastal and marine species, birds, plants, reptiles, amphibians and freshwater fishes is needed to provide a more complete picture of Liberia's biological wealth. Recommendations for safeguarding Liberia's globally significant biodiversity include developing large-scale aggregate biodiversity offsets, restoration in conservation priority sites that have already been degraded, allocation of additional resources for monitoring and enforcement of Liberia's wildlife laws, and strengthened management of the country's protected areas.

Junker J, Boesch C, Freeman T, Mundry R, Stephens C, Kuehl HS. 2015. Integrating wildlife conservation with conflicting economic land-use goals in a West African biodiversity hotspot. Basic and Applied Ecology 16:690–702

Tweh, C., Lormie, M., Kouakou, C. Y., Hillers, A., Kühl, H. S., Junker, J., et al. 2014. Conservation status of chimpanzees (Pan troglodytes verus) and other large mammals in Liberia: A nationwide survey. Oryx



Terrestrial Conservation Priority Areas

biodiversity priority area

50 km

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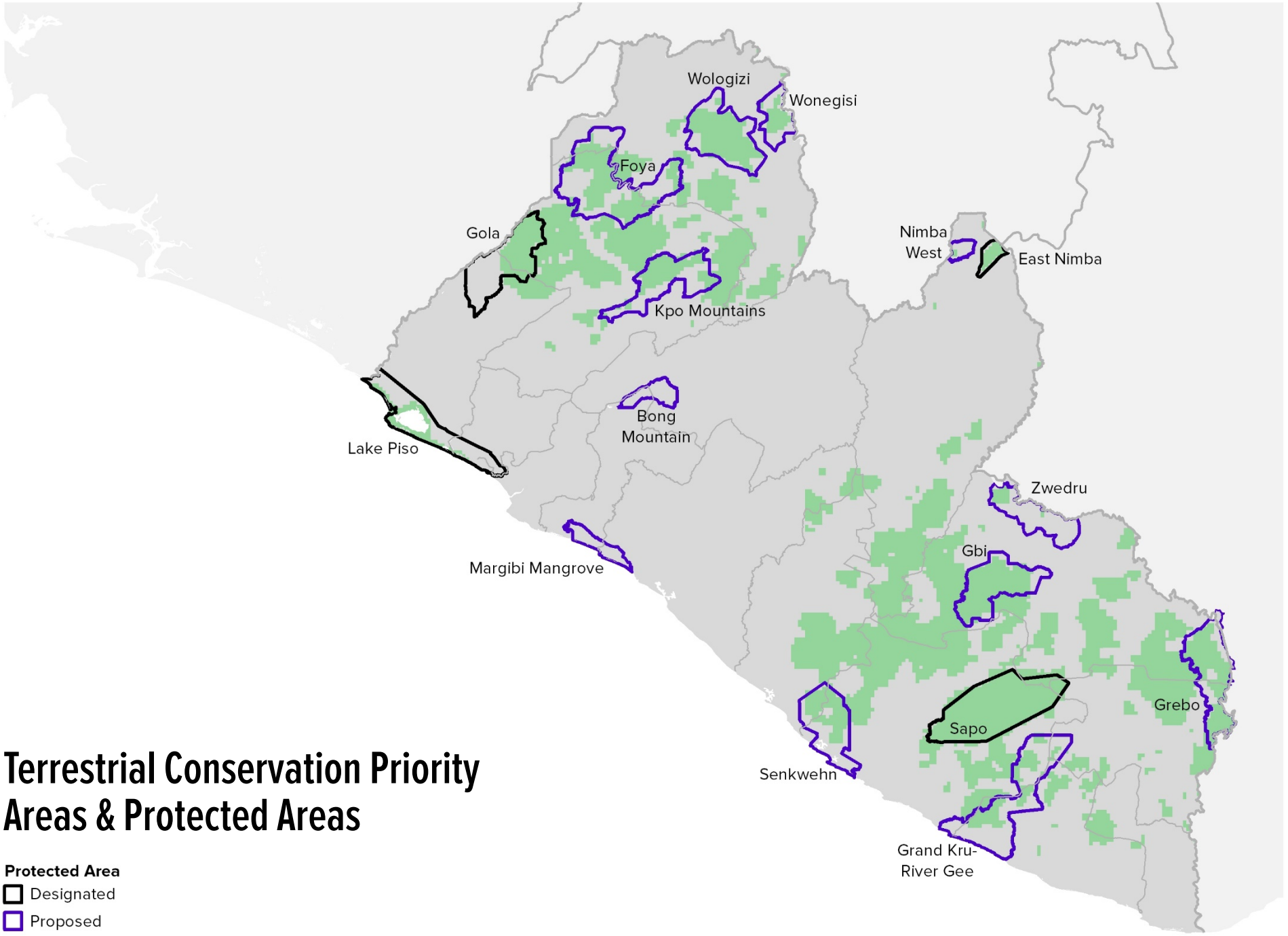


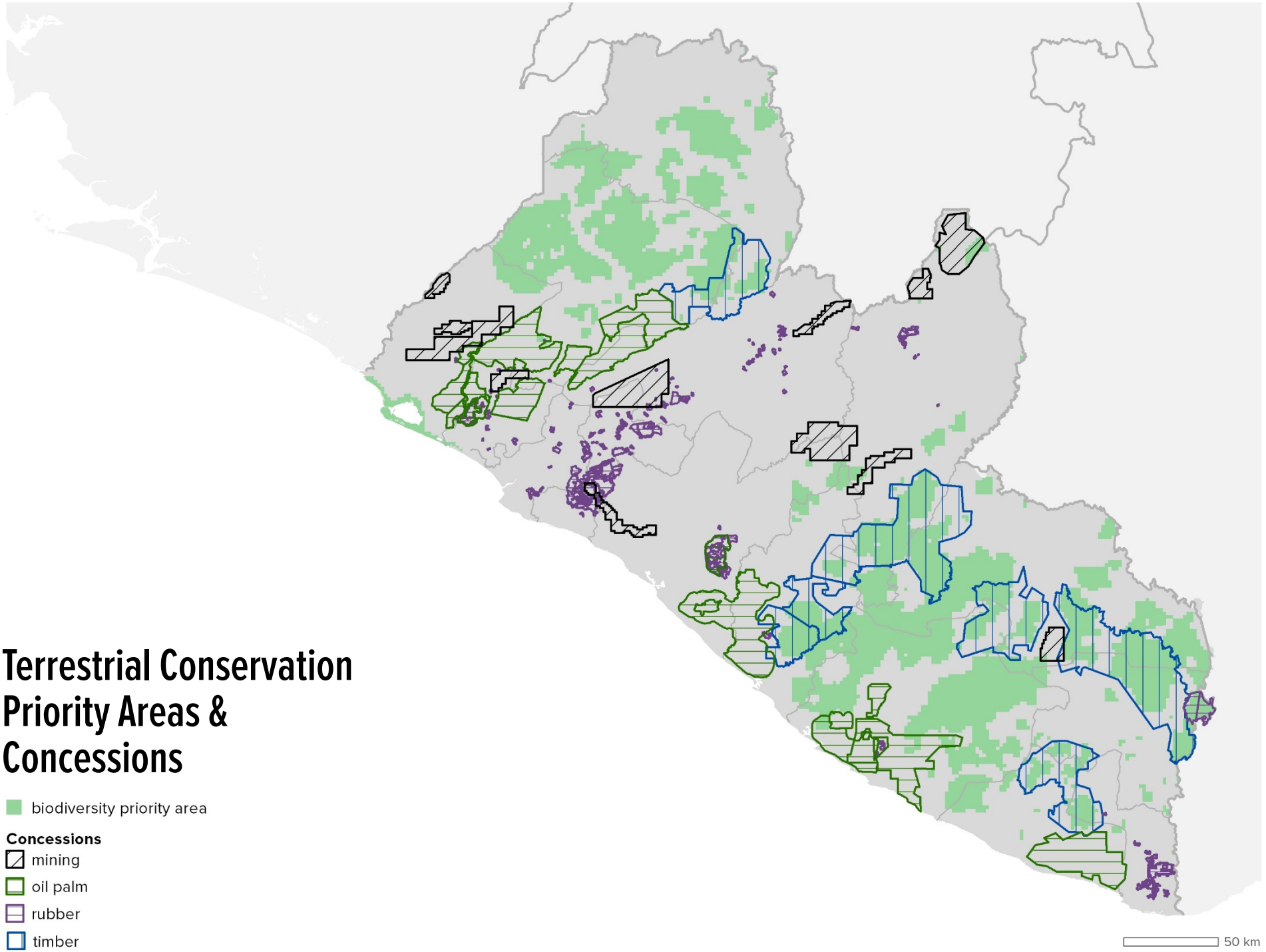
Terrestrial Conservation Priority Areas & Protected Areas

Protected Area

- Designated
- Proposed

- biodiversity priority area

Junker J, Boesch C, Freeman T, Mundry R, Stephens C, Kuehl HS. 2015. Integrating wildlife conservation with conflicting economic land-use goals in a West African biodiversity hotspot. Basic and Applied Ecology 16:690–702
IUCN and UNEP-WCMC (2016), The World Database on Protected Areas (WDPA) Cambridge, UK: UNEP-WCMC. Available at: www.protectedplanet.net.



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LISGIS (Liberia Institute of Statistics and Geo-Information Services.)

INSIGHT

ONLY 9% OF CONSERVATION PRIORITY AREAS ARE WITHIN DESIGNATED PROTECTED AREAS; IF PROPOSED PROTECTED AREAS WERE DESIGNATED, THIS FIGURE WOULD RISE TO 33% HOWEVER, 67% OF CONSERVATION PRIORITY AREAS FALL WITHIN CONCESSIONS

FOREST CARBON

MAX WRIGHT

FOREST CARBON

The forests of Liberia are the last remaining large intact tracts of forested land in western Africa, and contain some of the highest aboveground biomass carbon stocks of any forests in the world. Despite the acknowledged value of natural forest in Liberia for carbon storage, and other co-benefits, the forest continues to be lost to clearing for oil palm, rubber, and small-scale subsistence agriculture.

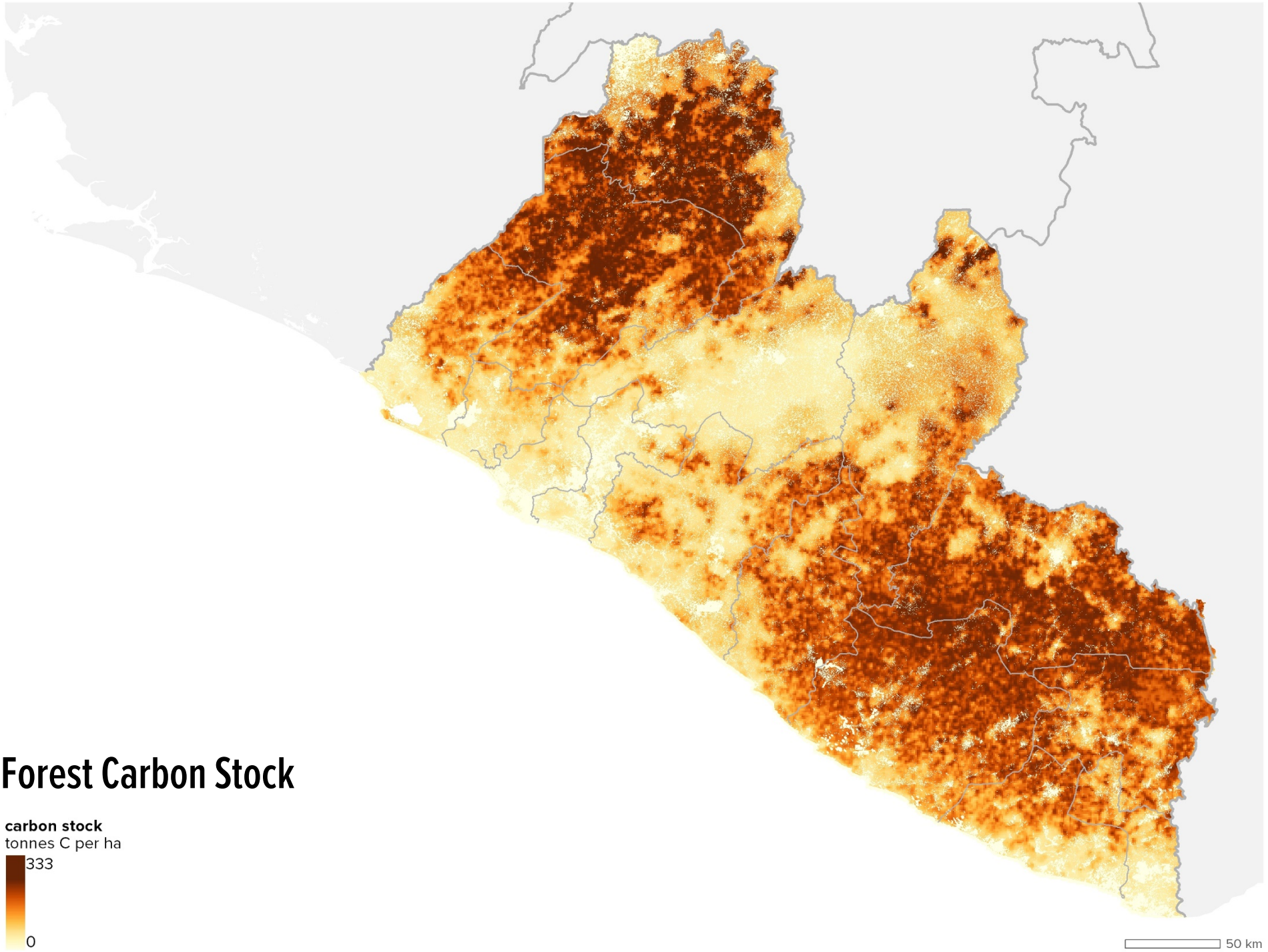
Understanding the spatial distribution of high biomass carbon forests allows decision makers to factor carbon storage into development decisions.

For our analyses, we combined two datasets: a 2015 land-cover map of Liberia (JV/Metria Geoville) and a global above-ground biomass map (Avitabile et al. 2016). We also looked at how forest carbon is distributed with land use types, such as protected areas and concessions.

There are two distinct regions of very high forest carbon stocks in Liberia, one in the northwest and one in the southeast. These remaining areas of intact forest are critical for carbon storage within Liberia. According to global estimates, the forests in northern Liberia have some of the highest density of above-ground biomass carbon in the world – higher even than in the Amazon rainforest. Liberia has relatively low forest carbon stock values in the central portion of the country. This is likely due to a high level of historic clearing associated with past human use. As one of the last remaining countries in west Africa with such high carbon stocks, it is imperative that Liberia's forests are maintained into the future.

The mean forest carbon stock is highest in ratified and proposed timber concessions. This would suggest that high carbon stock forests are preferentially chosen for timber extraction. In terms of green growth this could prove problematic as many of the highest carbon stock forests in Liberia contain essential natural capital and ecosystem service benefits. Another troublesome trend is that the current protected area network captures less than 5% of the forest carbon in the country. On a positive note, if all the proposed protected areas were designated this number would rise to almost 18%. Finally, we found much lower average carbon content in rubber plantations. This is likely because the rubber plantations are established under a rotating cultivation cycle, but it has large implications for their average biomass. If rubber and oil palm plantations expand in an unsustainable fashion, high carbon natural forest will increasingly be replaced by lower carbon forest crops, which will have broad implications for climate and biodiversity at a global scale.

Avitabile V et al. 2016. An integrated pan-tropical biomass map using multiple reference datasets. Global Change Biology 22:1406–1420.
JV Metria/Geoville. 2015. Liberia Land Cover and Forest Mapping 2015. JV Metria/Geoville and Forestry Development Authority, Monrovia, Liberia.



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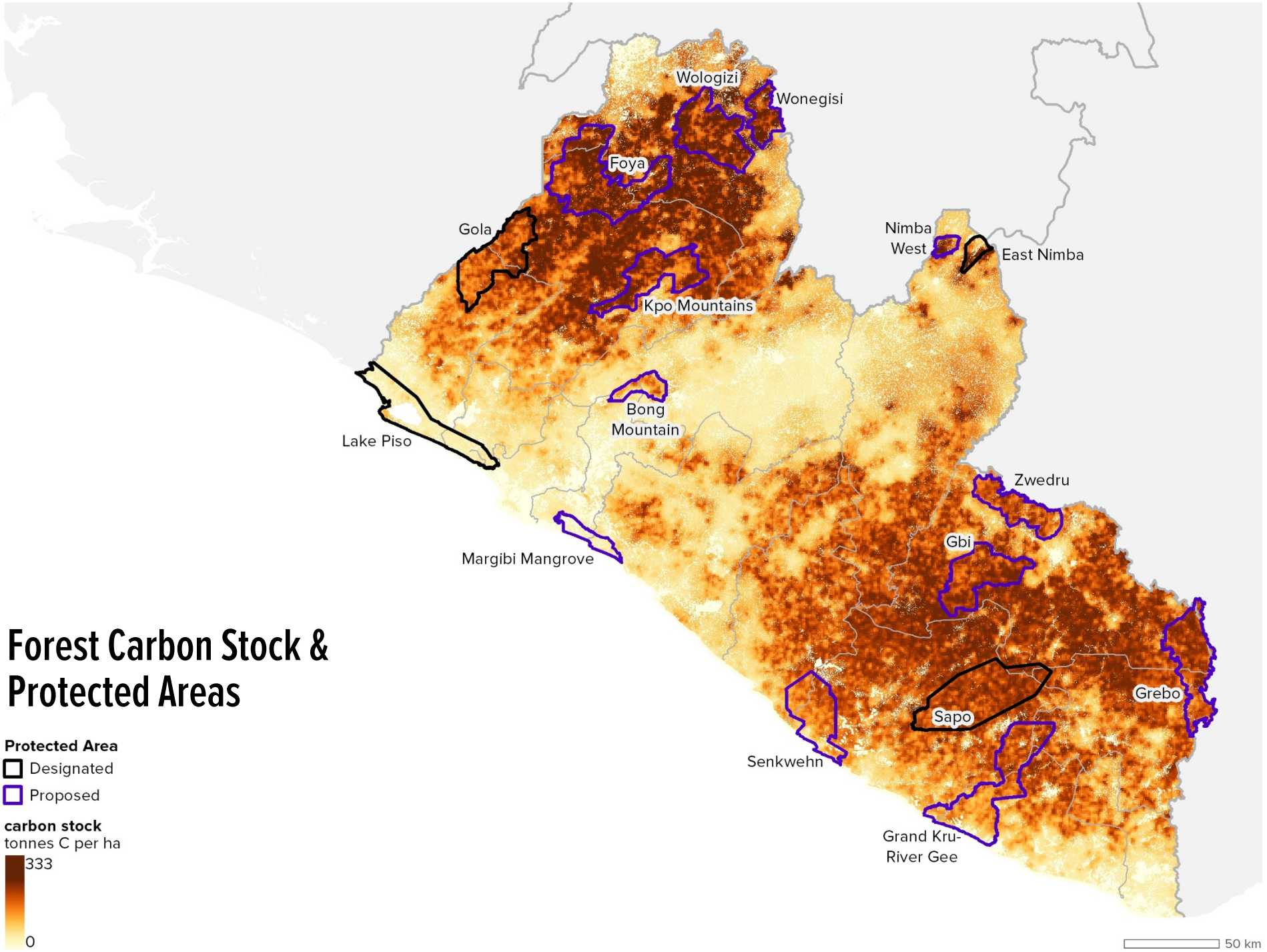

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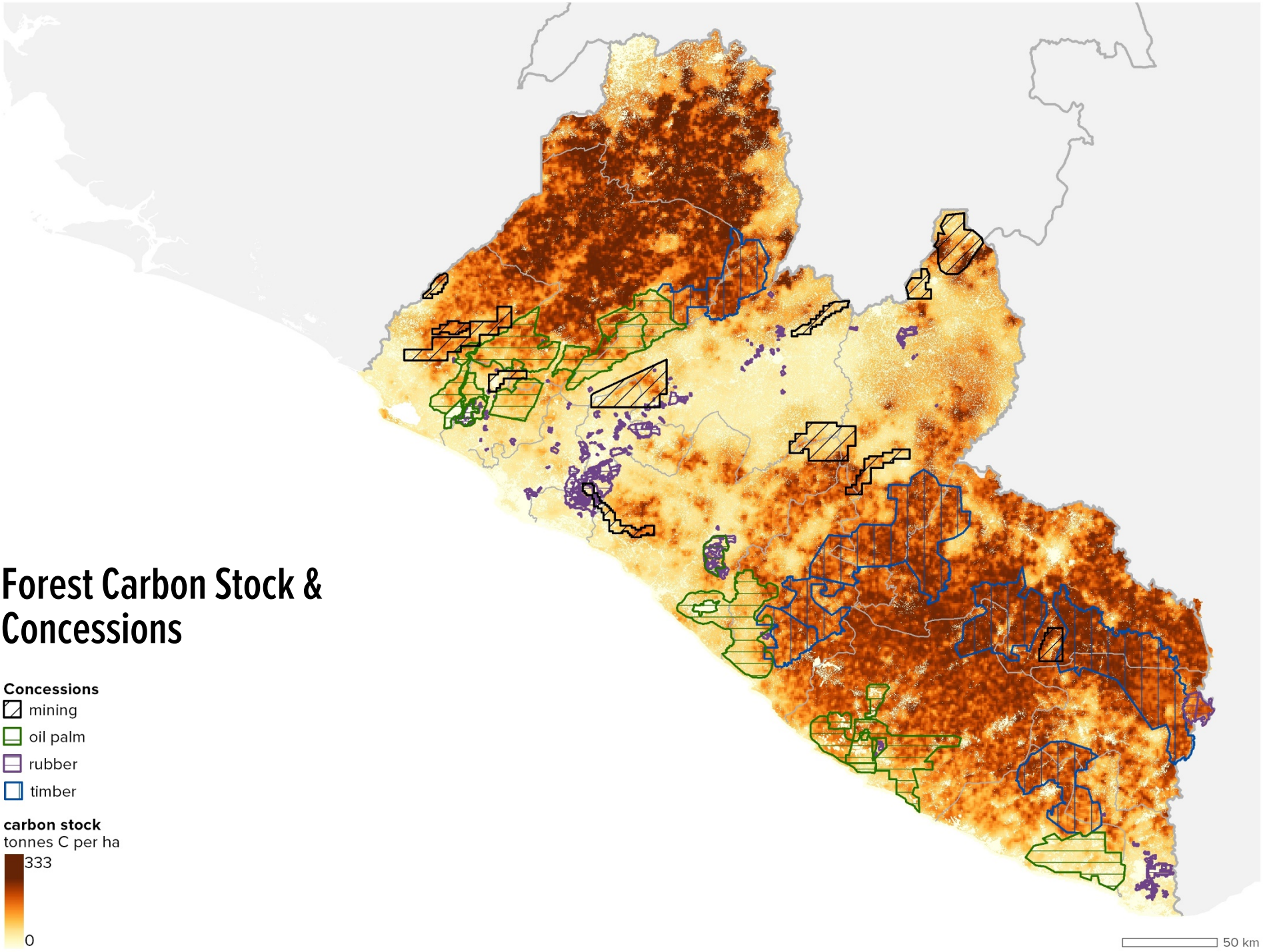
IUCN and UNEP-WCMC (2016), The World Database on Protected Areas (WDPA) Cambridge, UK: UNEP-WCMC. Available at: www.protectedplanet.net



Avitabile V et al. 2016. An integrated pan-tropical biomass map using multiple reference datasets. Global Change Biology 22:1406–1420.
JV Metria/Geoville. 2015. Liberia Land Cover and Forest Mapping 2015. JV Metria/Geoville and Forestry Development Authority, Monrovia, Liberia.
LISGIS (Liberia Institute of Statistics and Geo-Information Services.)

FOREST COVER & LAND USE

Table 4. Carbon stocks (2015) by land-use designation

	Area (ha)	Proportion of total area	Mean (tC/ha)	Total forest carbon 2015	Proportion of forest carbon
Liberia Total	9594063.7	-	158.59	15215623958	-
Proposed protected area	909597.3	9.5%	218.73	1989606210	13.1%
Designated protected area	362336.9	3.8%	180.15	652741516.6	4.3%
Ratified timber concession	1007782.1	10.5%	223.65	2298076166	15.1%
Proposed timber concession	1257945.8	13.1%	233.17	2933188135	19.3%
Oil Palm plantations	696876.5	7.3%	119.75	834535211.7	5.5%
Rubber plantations	94302.4	1.0%	30.58	28838352.24	0.2%

Conservation International. 2017. Natural Capital Mapping and Accounting in Liberia: Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development. Arlington, VA. 97 pp.

INSIGHT

THE CURRENT PROTECTED AREA NETWORK CAPTURES LESS THAN 5% OF THE FOREST CARBON IN LIBERIA. IF ALL PROPOSED PROTECTED AREAS WERE DESIGNATED THIS NUMBER WOULD RISE TO 18%

HOWEVER, 21% OF THE FOREST CARBON IN LIBERIA FALLS WITHIN RATIFIED TIMBER, RUBBER, OR OIL PALM CONCESSIONS

VULNERABILITY TO TREE COVER LOSS

MAX WRIGHT

VULNERABILITY TO TREE COVER LOSS

We analyzed vulnerability to future tree cover loss based on tree cover loss trends from 2000-2014. We use the term “tree cover loss” instead of “deforestation” because our analysis is based on a global dataset which includes the loss of both natural forest and plantation forest trees.

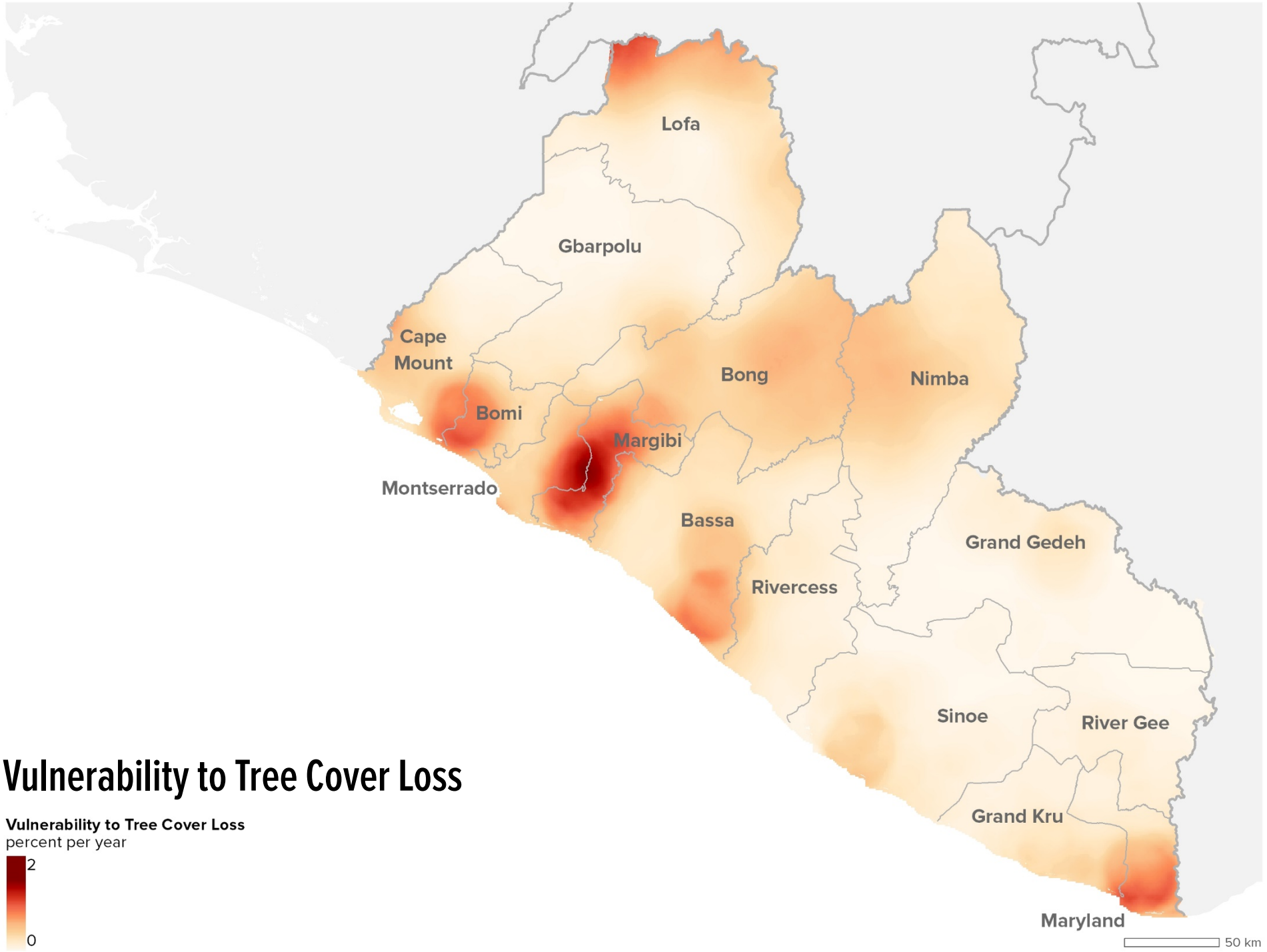
We used two datasets for this analysis: a 2015 land-cover map of Liberia (JV/Metria Geoville) and global data on tree cover loss 2000-2014 (Hansen et al. 2013). To create the map of vulnerability to tree cover loss, a simple proximity-based model was applied. The model assigned an annual rate of tree cover loss to each pixel based on the observed historical annual rate of tree cover loss. Pixels that were forested as of 2015, located near pixels that were recently cleared, were considered “vulnerable” to future tree cover loss.

Our analysis indicates that areas around oil palm and rubber plantations have high vulnerability to future tree cover loss. Some of the tree cover loss in these areas is due to clearing of secondary forest or rotational cultivation, therefore it is not possible to determine how much of the vulnerability can be attributed to the loss of natural forest versus clearing of plantation trees. The center of the country, in Bong and Nimba counties, also shows widespread vulnerability to tree cover loss, likely due to small-scale clearing for human use, subsistence agriculture or charcoal production. A third hotspot for tree cover loss is found in Lofa county in the north. This area is on the border of the country where there have been proposals to create a transboundary protected area. This area also has relatively higher population density which may mean that this area is also being subjected to small-scale clearing for agriculture or other human use, and there are reports of forest fires which may explain some of the pattern of vulnerability.

Forested areas of Lofa and Nimba counties, which have both high vulnerability to tree cover loss and high carbon stocks, might be good candidates for carbon financing. More detailed ground truthing and analysis based on field sampling would need to be conducted if a REDD+ or other carbon-based conservation mechanism were to be employed, however.

We also explored rates of tree cover loss and forest carbon stocks by land use designation. Not surprisingly rubber plantations had the highest rate of tree cover loss from 2000—2015, likely reflecting established plantations with regular cultivation cycles. In oil palm plantations, the annual tree cover loss rate between 2000—2015 was twice the national average (0.06%), accounting for almost 15% of the total tree cover loss over the observation period. This could indicate clearing of forested land for new palm oil plantations, rather than a regular cultivation cycle. Interestingly, the tree cover loss rate in proposed protected areas was lower than in designated protected areas during the study period. This may be because areas proposed for protection may not have many competing land-uses, which is not uncommon as it would reduce the opportunity cost for their creation.

Hansen MC et al. 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342:850–853.
JV Metria/Geoville. 2015. Liberia Land Cover and Forest Mapping 2015. JV Metria/Geoville and Forestry Development Authority, Monrovia, Liberia.



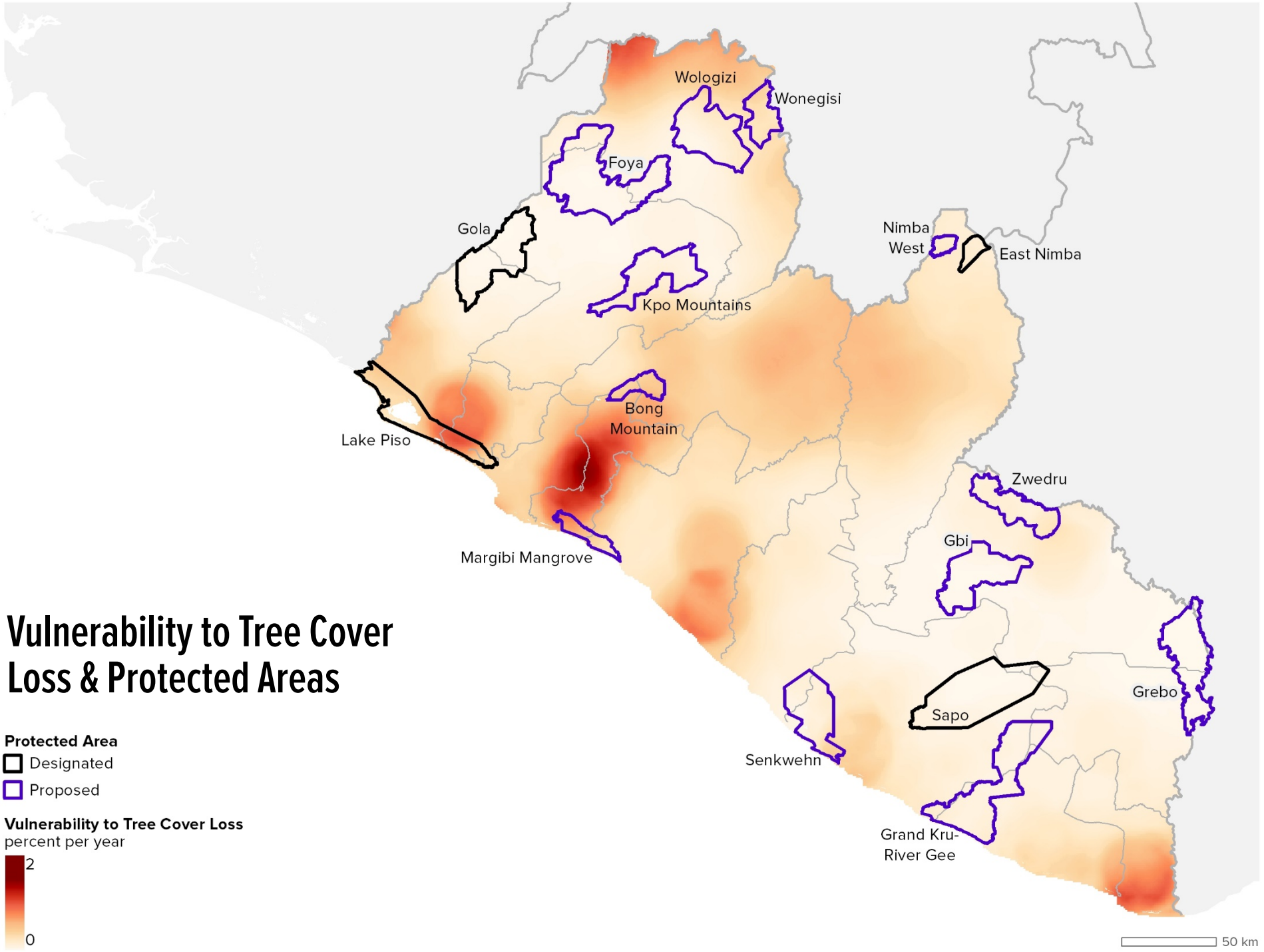
Vulnerability to Tree Cover Loss

Vulnerability to Tree Cover Loss
percent per year

2

0

Hansen MC et al. 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342:850–853.
JV Metria/Geoville. 2015. Liberia Land Cover and Forest Mapping 2015. JV Metria/Geoville and Forestry Development Authority, Monrovia, Liberia.



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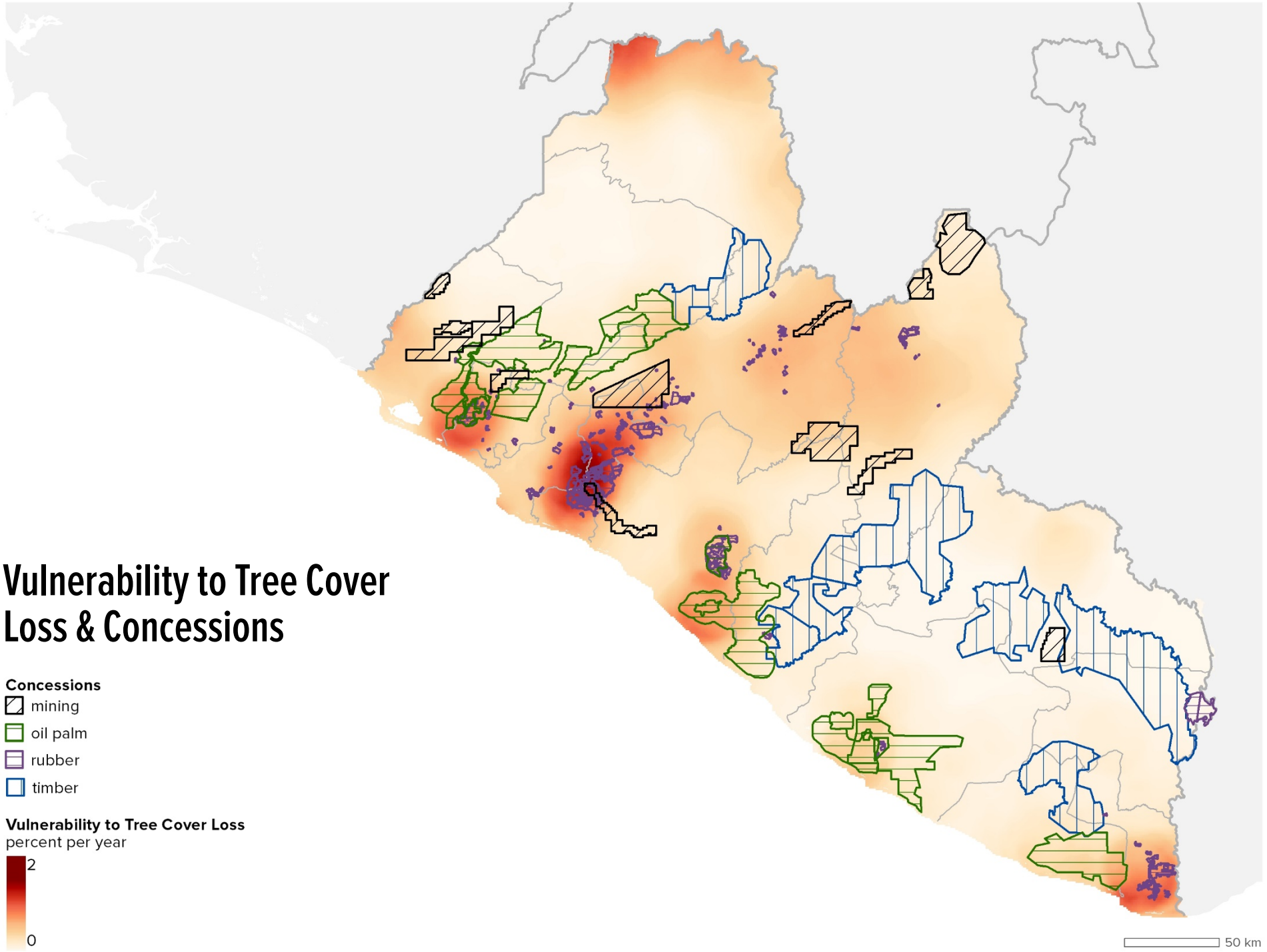

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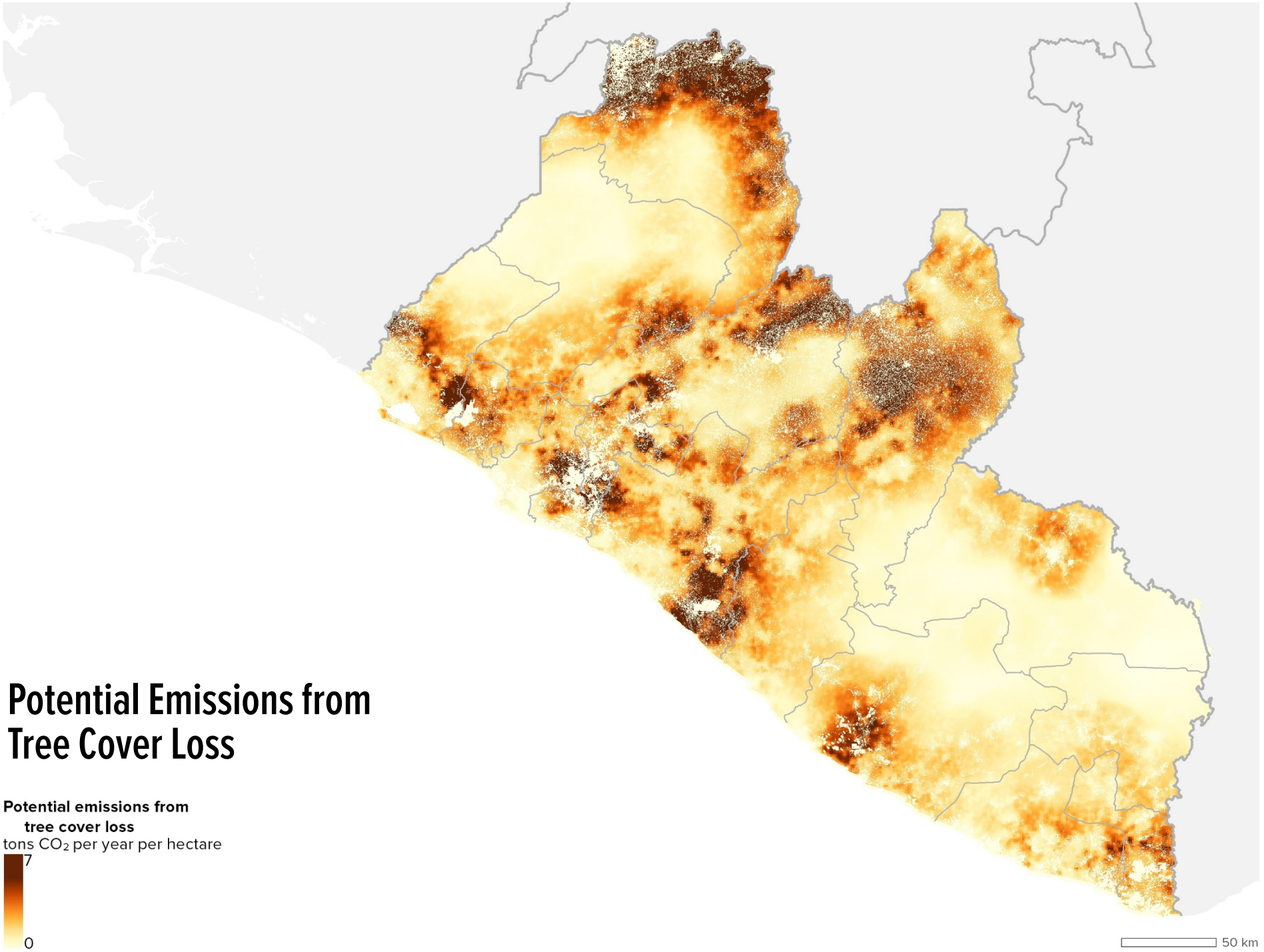

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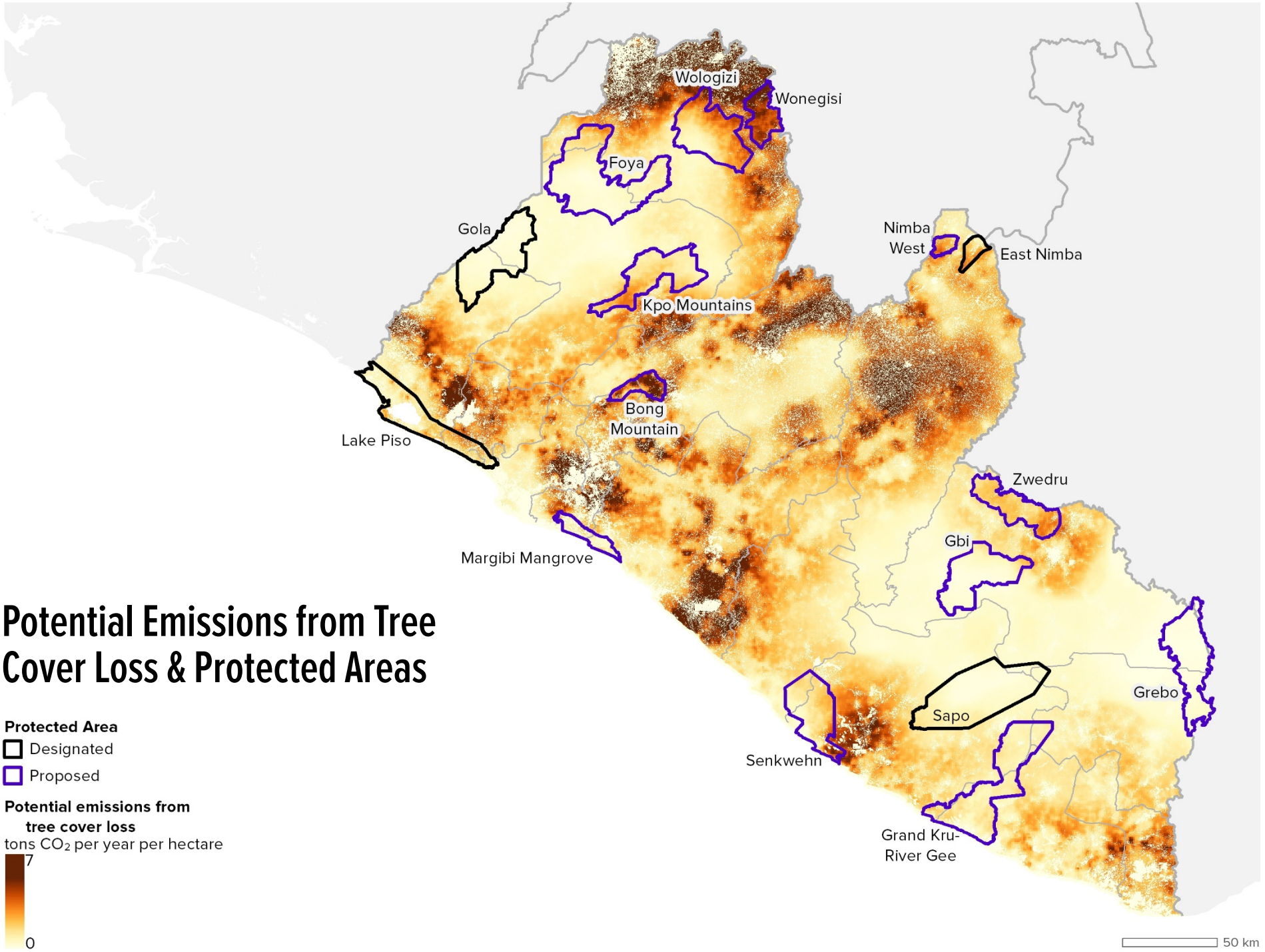

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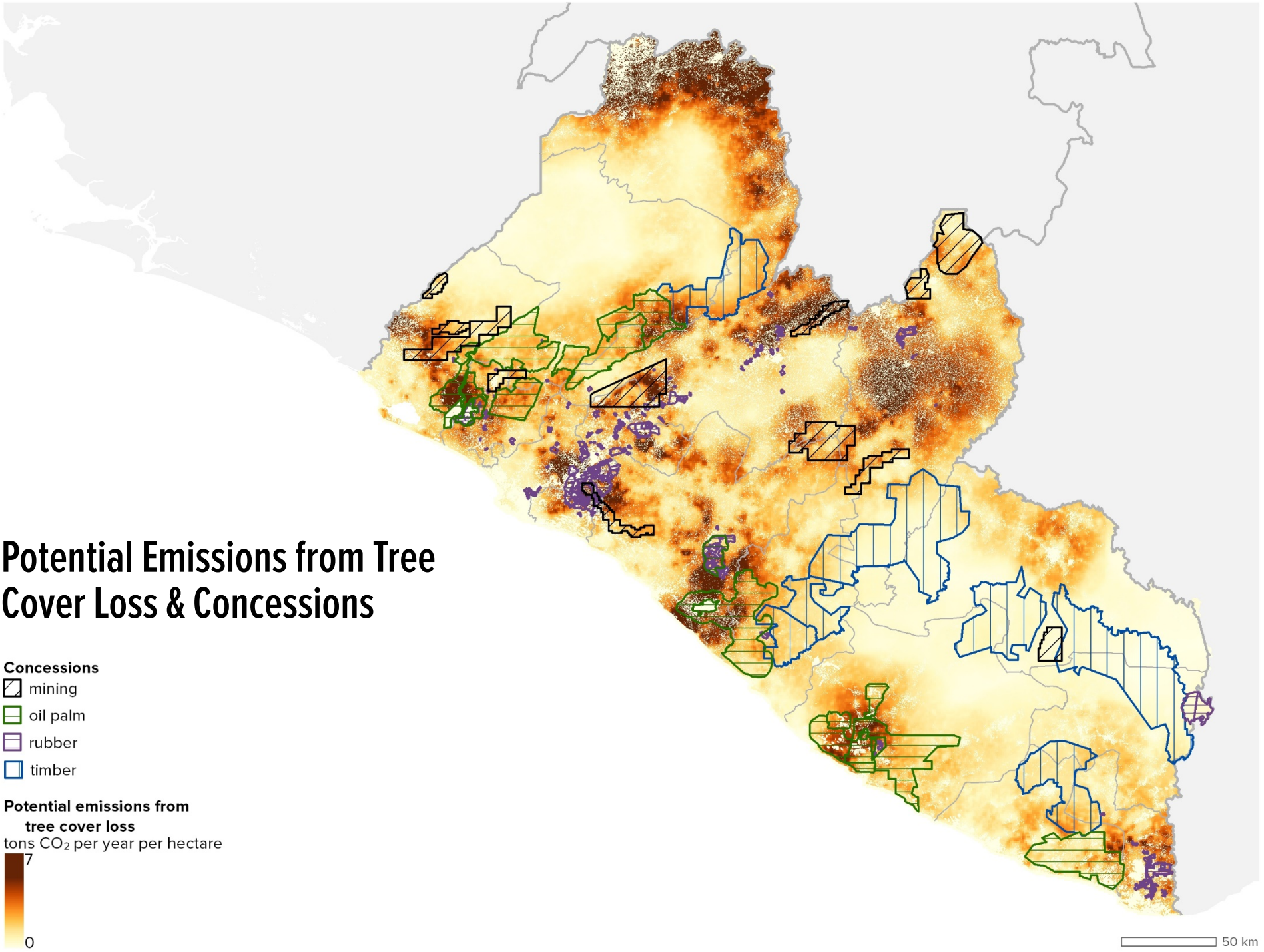

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LISGIS (Liberia Institute of Statistics and Geo-Information Services.)

FOREST PRODUCTS

KELLEE KOENIG AND RACHEL NEUGARTEN

FOREST PRODUCTS

In Liberia, forests provide edible plants, fruits, nuts, and habitat for wildlife which is hunted for bushmeat, as well as firewood used for cooking. About 70 percent of Liberia's rural population earn their living from forests. Freshwater, marine, and coastal ecosystems such as mangroves provide fish, shrimp, shellfish, and other products that support food security. Data on which habitats provide the most food security benefits in Liberia are not available at the national scale. Therefore, we used the accessibility of natural habitats (forests, grasslands, mangroves & swamps, and shrublands) to people as a proxy indicator. Accessibility was modeled based on population, roads, land cover types, slope, and other variables. This model is based on the assumption that natural habitats that are more accessible to people are providing more non-timber forest products than habitats which are more difficult to access. We found that the most accessible natural habitats are located along the central part of Liberia, along the coast, and along roads.

These areas may be subjected to unsustainable levels of harvest and could be priorities for further research to establish sustainable levels of harvesting for different species. These areas could also be prioritized for the establishment of sustainable management regimes (such as community conservation agreements) to ensure that rare and endangered species are not over-harvested. Finally, these areas could be prioritized for monitoring and enforcement of existing regulations, such as for protected species.

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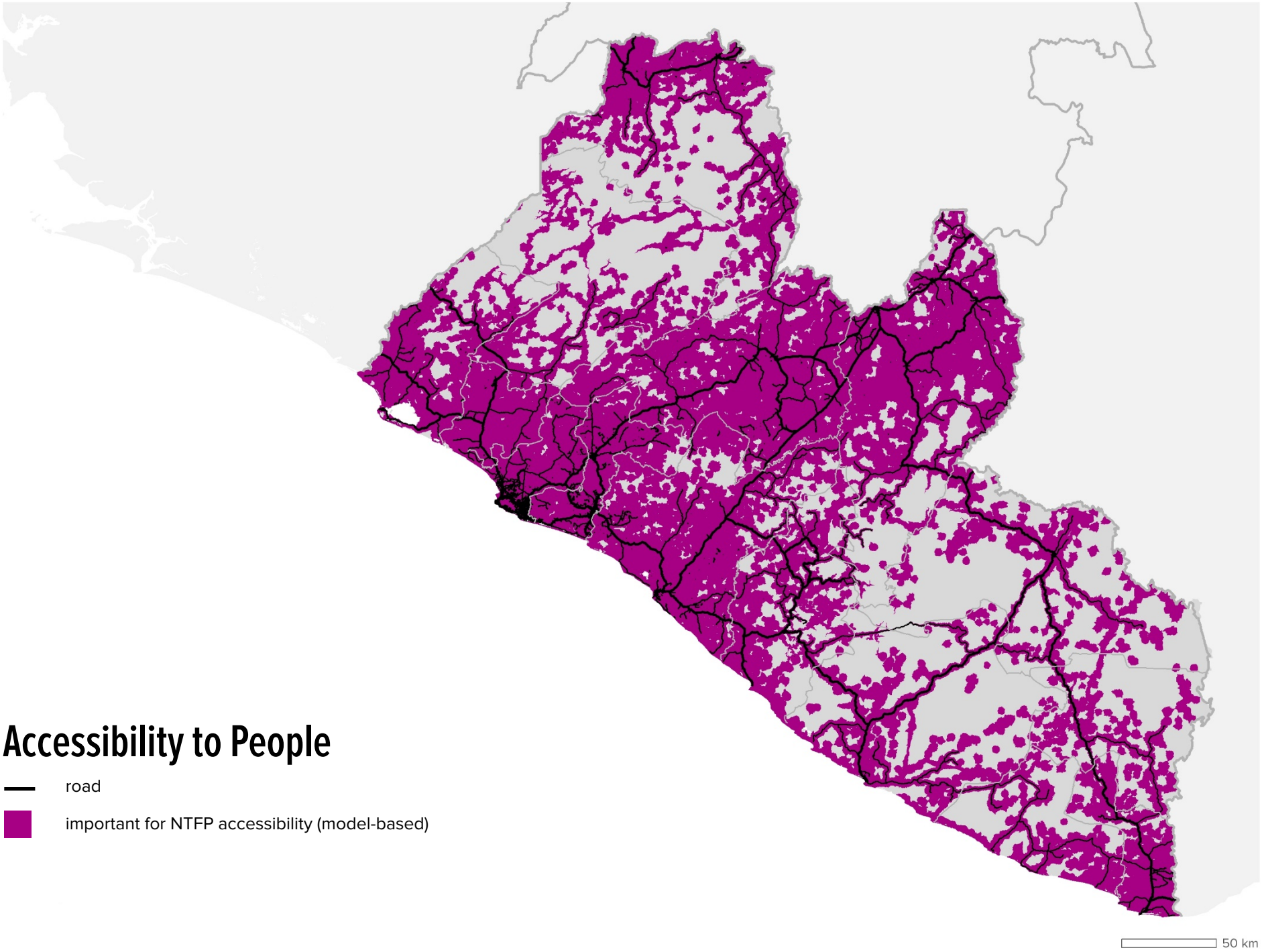
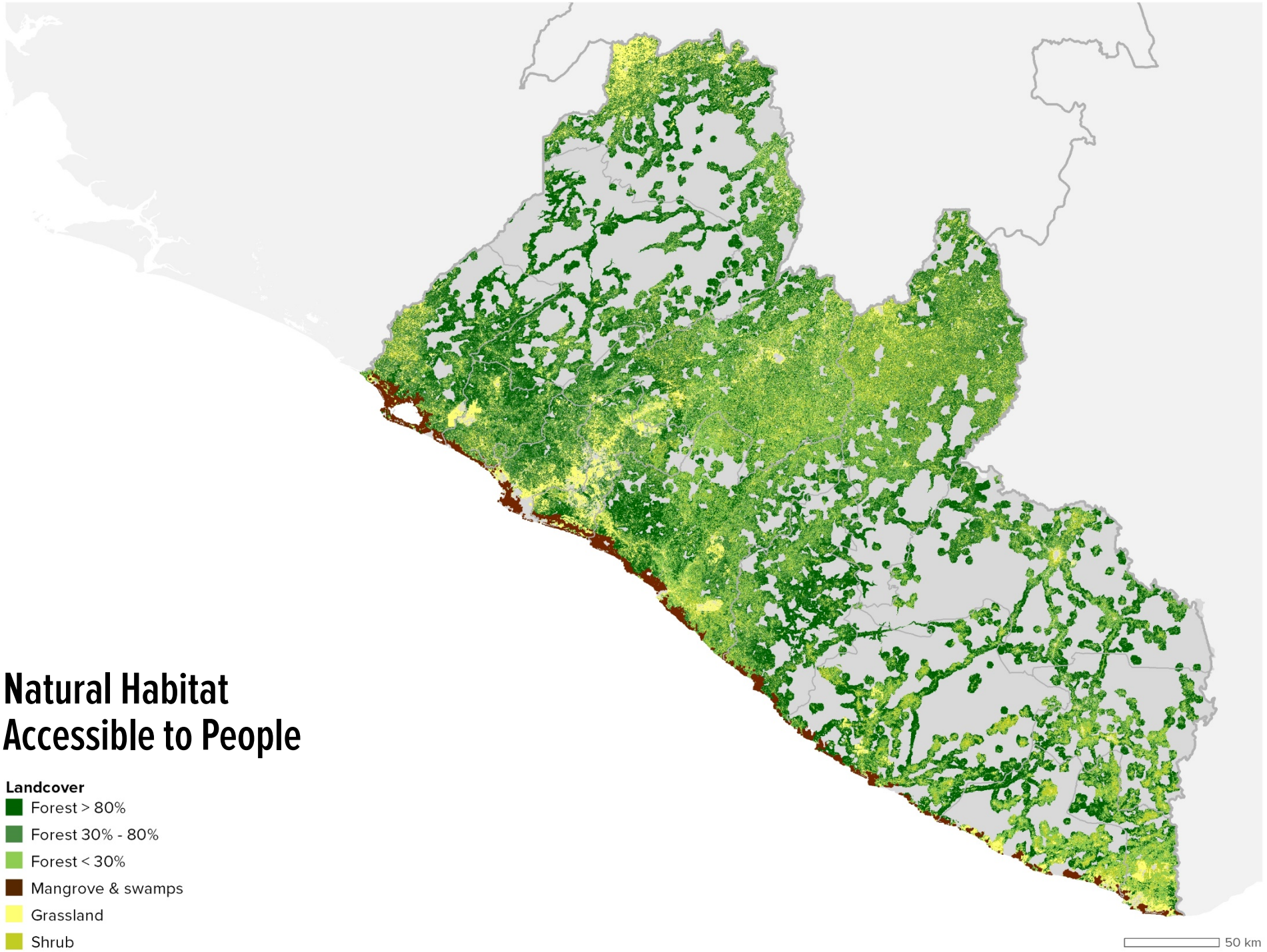
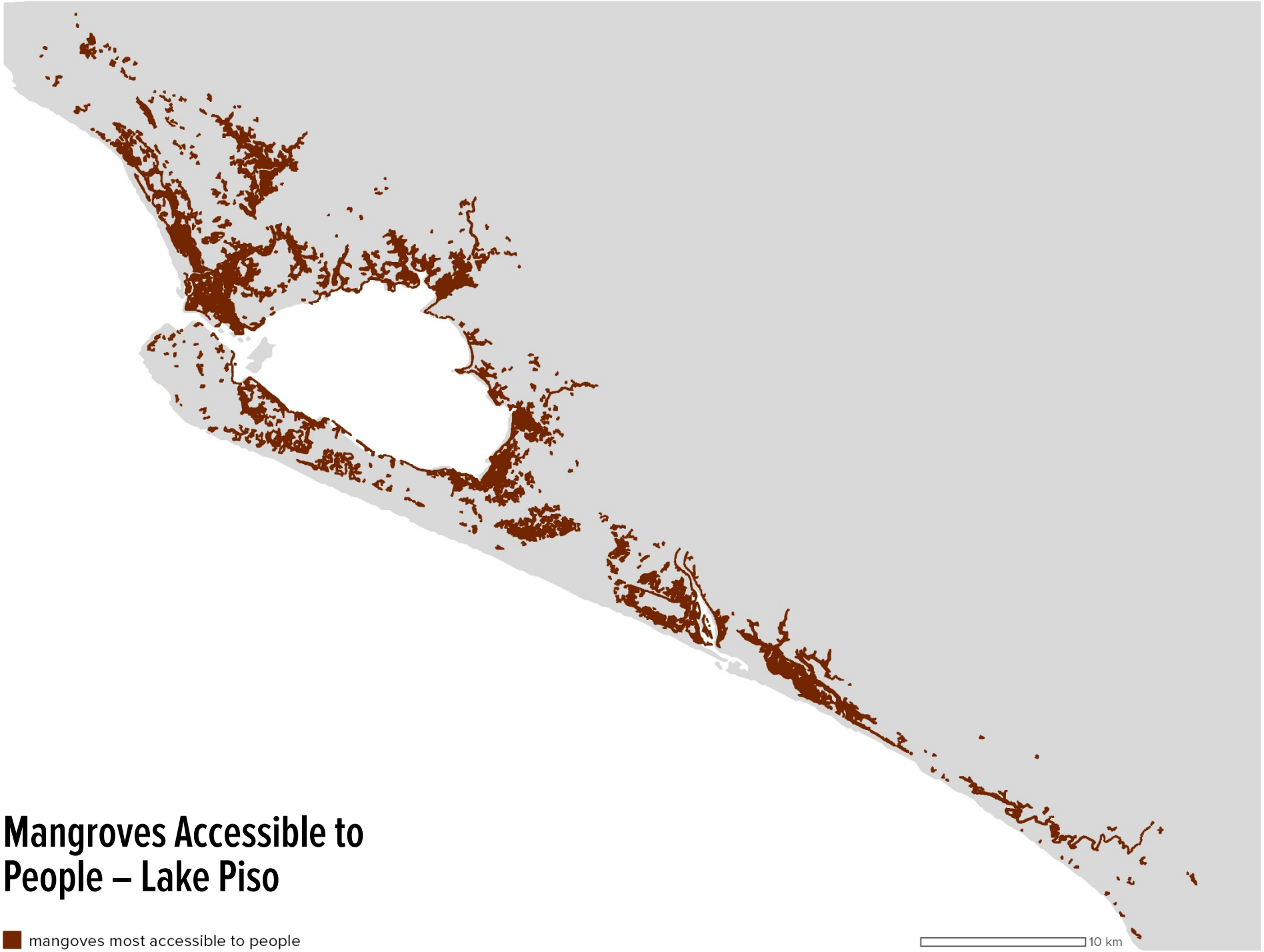


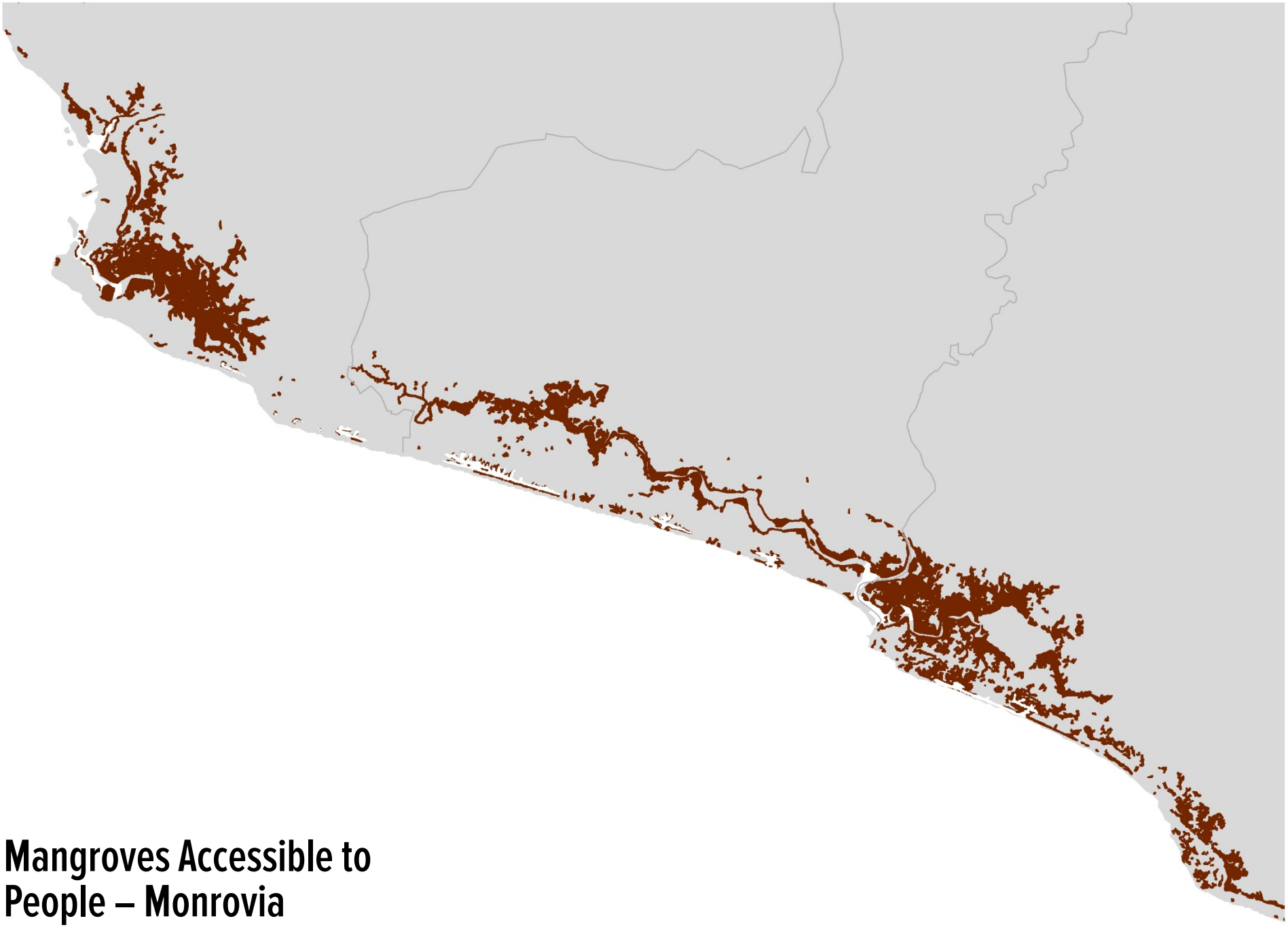
Porro R et al. 2008. Challenges to Managing Ecosystems Sustainably for Poverty Alleviation: Securing Well-Being in the Andes/Amazon. Situation Analysis prepared for the ESPA Program. Amazon Initiative Consortium,. ESPA-AA, Belém, Brazil. For complete data sources see Conservation International. 2017. Natural Capital Mapping and Accounting in Liberia: Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development.



Porro R et al. 2008. Challenges to Managing Ecosystems Sustainably for Poverty Alleviation: Securing Well-Being in the Andes/Amazon. Situation Analysis prepared for the ESPA Program. Amazon Initiative Consortium,. ESPA-AA, Belém, Brazil. For complete data sources see Conservation International. 2017. Natural Capital Mapping and Accounting in Liberia: Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development.



For data sources see Conservation International. 2017. Natural Capital Mapping and Accounting in Liberia: Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development.



Mangroves Accessible to People – Monrovia

mangoves most accessible to people

10 km

For data sources see Conservation International. 2017. Natural Capital Mapping and Accounting in Liberia: Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development.

VULNERABILITY TO FLOODING

MIROSLAV HONZAK AND NATALIA ACERO

FLOOD REGULATION

Natural ecosystems such as forests, wetlands, and other aquatic ecosystems play a vital role in the hydrological cycle, as they regulate water flows in a landscape. For example, cloud forests have the ability to intercept atmospheric water and through the process of evapotranspiration, return part of it back to the atmosphere. Soils containing abundant root systems, especially the root systems of trees, prevent soil erosion and exhibit a high infiltration rate that is important for groundwater recharge. Wetlands and marshes also reduce the velocity of water flows, reducing flood and drought risk.

We analyzed the flood (flow) regulation function of vegetation using algorithms that connected downstream vulnerable populations to natural capital that regulates water flow. The following datasets were used: outputs of the WaterWorld modeling tool (Mulligan et al. 2013). Areas at risk of flooding were based on a map produced for the Global Assessment Report on Risk Reduction (UNEP, 2009). Water flow direction was derived from the HydroSHEDS dataset (Lehner et al., 2008). For estimating the number of people in floodplains we used 2007 population data from LandScan (Bright et al., 2008).

Our analysis indicates that conserving vegetation cover in the watershed surrounding and immediately upstream of Monrovia is the most important area to reduce the risk of flooding for a large number of vulnerable people downstream.

Bright EA, Coleman PR, Rose AN, Urban ML. 2012. LandScan 2011. Oak Ridge National Laboratory. Available from http://web.ornl.gov/sci/landscan
Lehner, B., Verdin, K., Jarvis, A. (2008) New global hydrography derived from spaceborne elevation data. Eos, Transactions, AGU, 89(10): 93-94.
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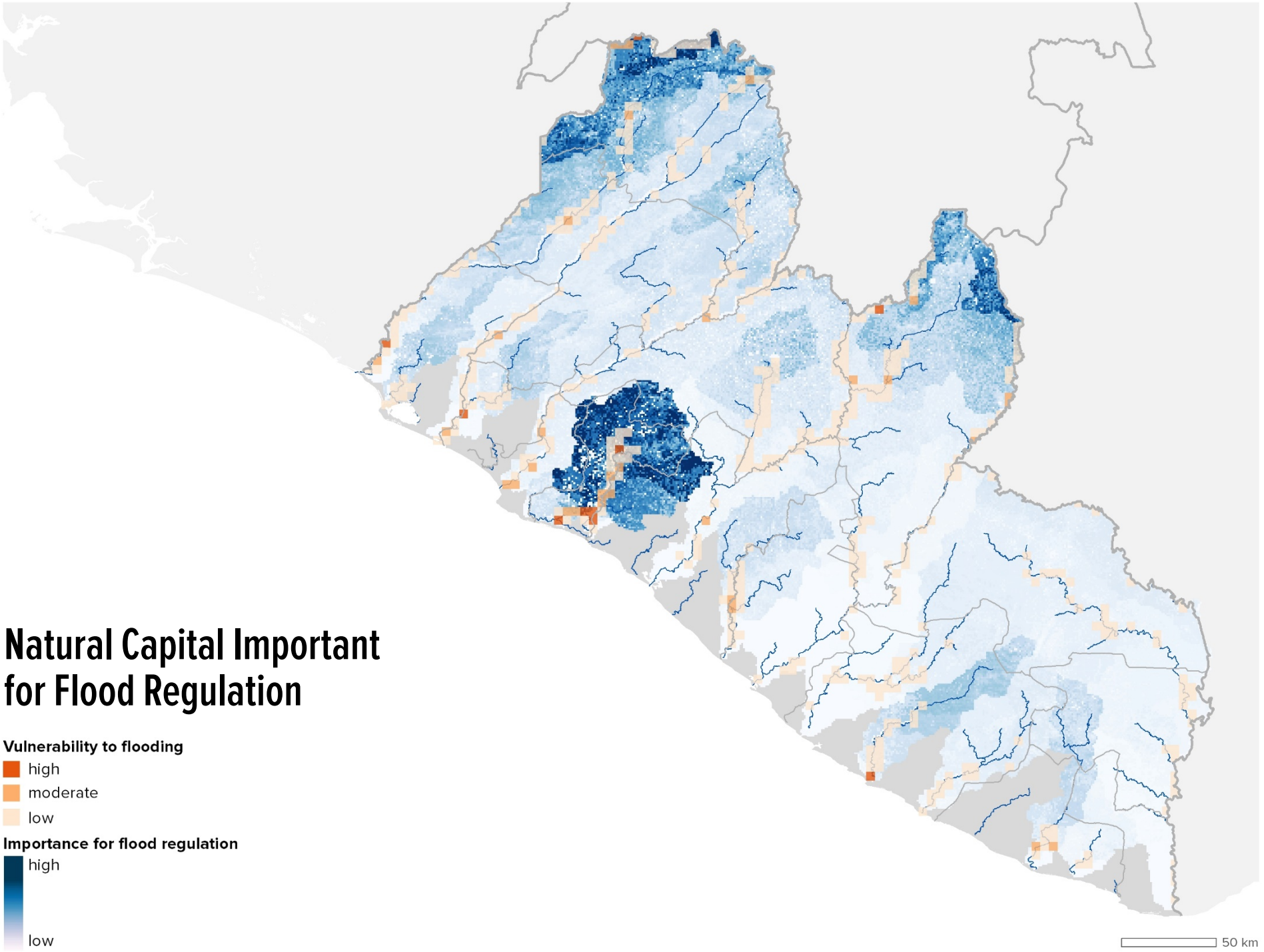
UNEP (2009) 2009 Global Assessment Report on Disaster Risk Reduction: Risk and poverty in a changing climate. Available at: http://www.preventionweb.net/gar09 (accessed on November 21, 2016).



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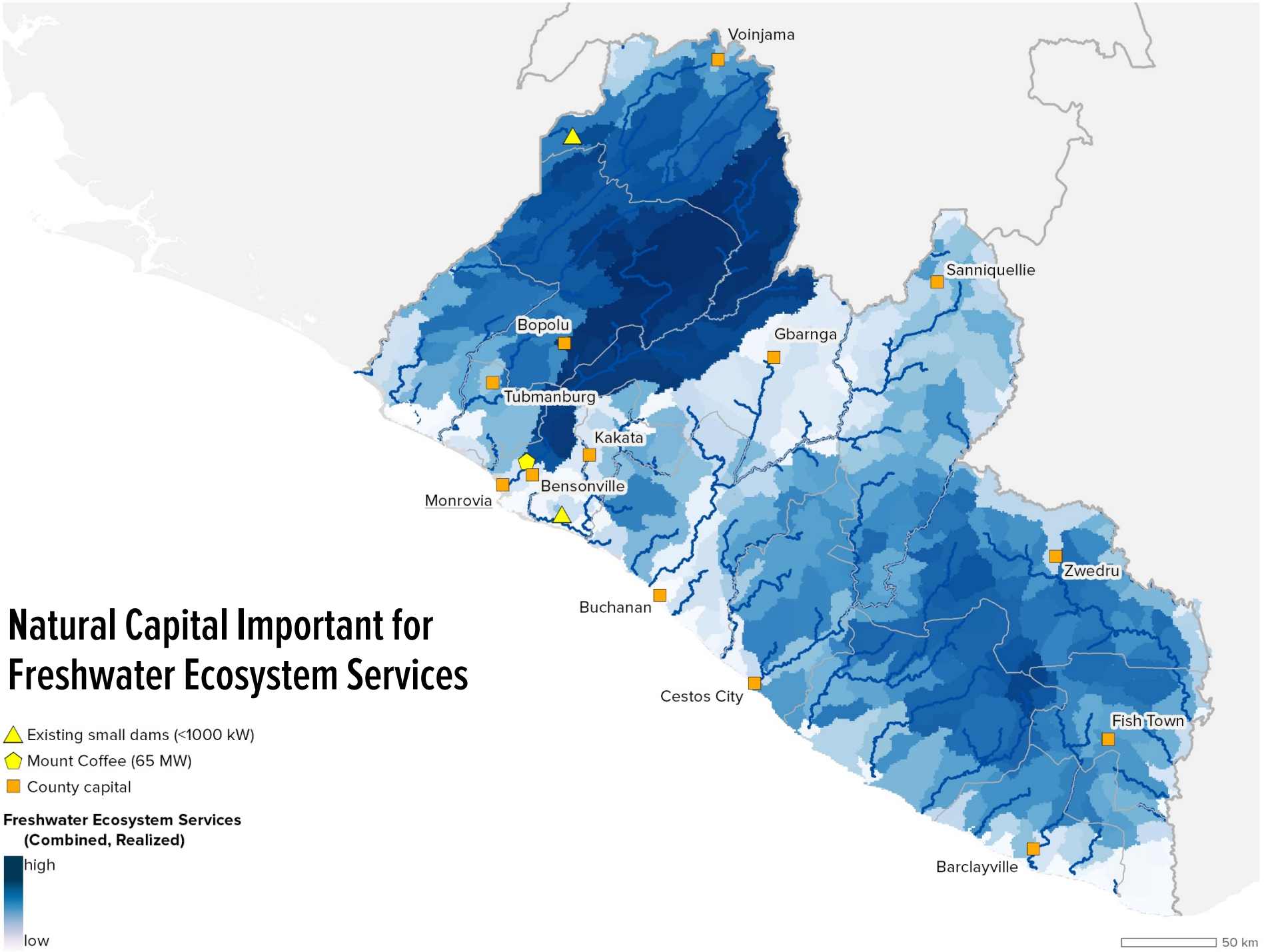
Mulligan M. 2013. WaterWorld: a self-parameterising, physically based model for application in data-poor but problem-rich environments globally. Hydrology Research 44:748.

FRESHWATER ECOSYSTEM SERVICES

MIROSLAV HONZAK AND NATALIA ACERO

FRESHWATER

Although fresh water is not a scarce resource in Liberia, it is vital resource important for people and the economy. People rely on water for drinking and household use as well as for hydropower generation. 61% of people do not have access to clean water, and 95% of people do not have access to public electricity, despite Liberia's high potential for hydropower production. Natural ecosystems such as forests and wetlands regulate water flows, capture sediment, and recycle nutrients, which support the stable production of electricity and improves water quality. For our analysis, we modeled three ecosystem services: freshwater quantity, quality, and flow regulation, using WaterWorld modeling tool (Mulligan et al. 2013). A combined map was generated by averaging the values of the three maps, then weighted using the location of the population centers and hydropower dams and their estimated demand for water services. In Liberia, there are three important areas for potential freshwater services (those that are being provided by nature, even if people are not using them). The first corresponds to an area of natural forest located around the Wologizi and Wonegizi Ranges. The southern two regions are located around the Putu Range. We recommend that vegetation cover should be maintained or restored in these watersheds to reduce erosion, ensure that rivers downstream do not become clogged with sediment, and ensure predictable flows of water for existing or future hydropower generation. In terms of realized freshwater services (those that are currently benefitting people), the area upstream of Monrovia is relatively more important due to the demand for water from this large population center and the Mount Coffee hydropower dam. This area should be targeted for conservation or payments for ecosystem services (PES) to maintain and enhance the provision of freshwater services for Monrovia and the Mount Coffee hydroelectric dam. The upper watershed of the St. Paul River in Lofa county, as well as the upper Cestos River watershed in Nimba county, should also be targeted for conservation to maintain the provision of freshwater ecosystem services for current and future hydropower generation.



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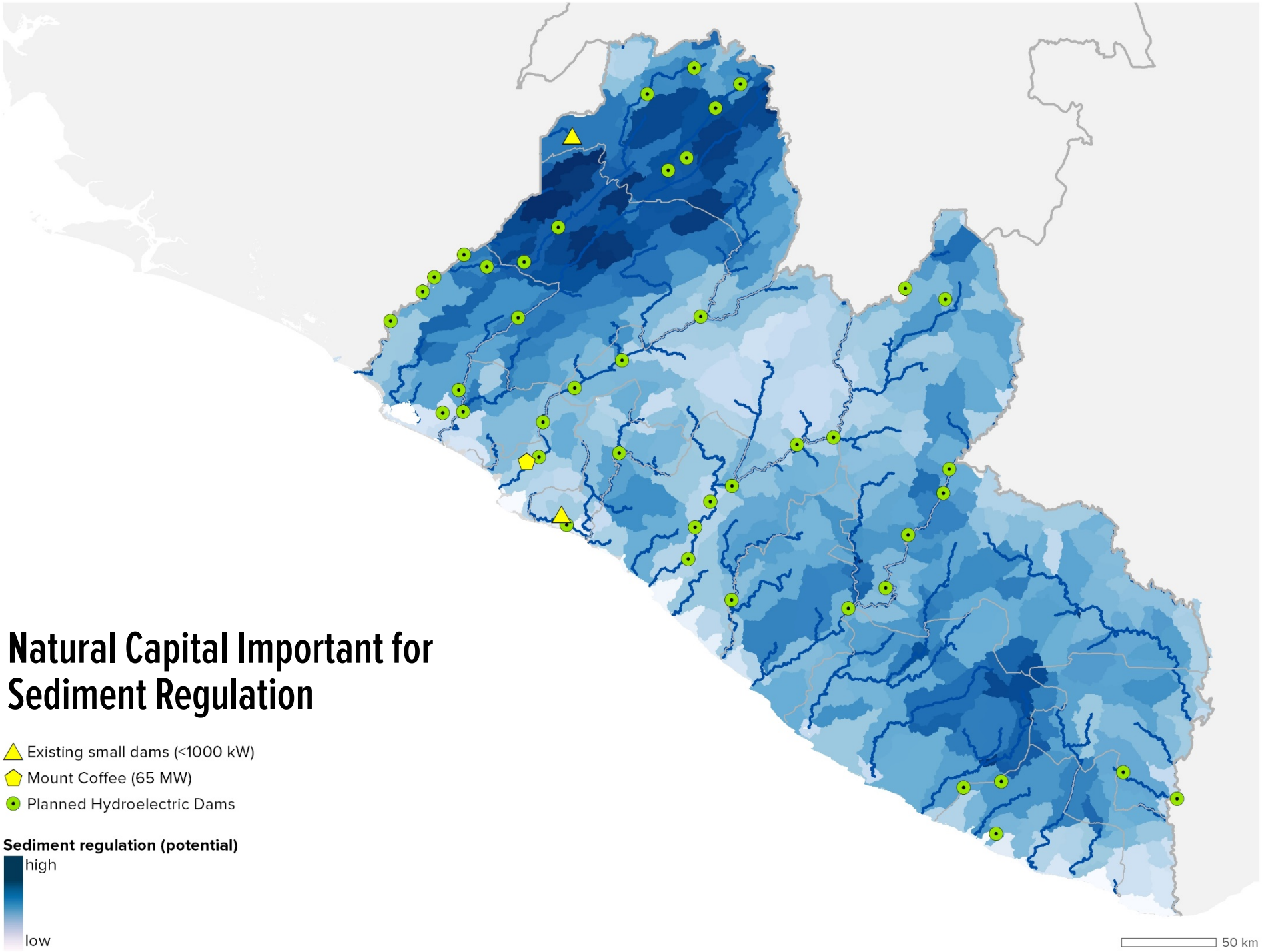

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COASTAL PROTECTION

KEVIN MOULL AND RACHEL NEUGARTEN

COASTAL PROTECTION

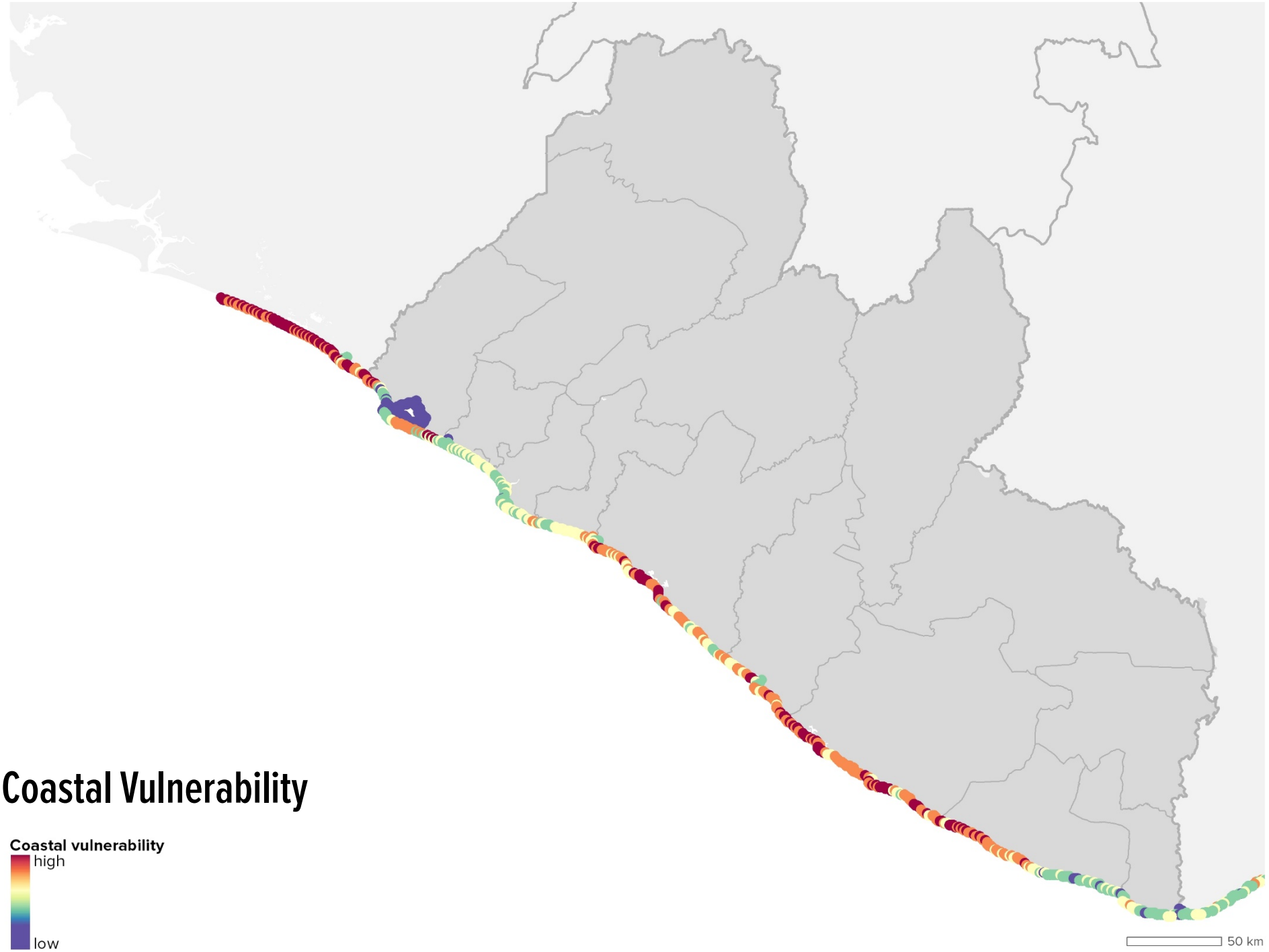
In Liberia, coastal mangroves provide numerous benefits to people. Mangroves provide fish nursery habitat, as well as providing sources of crabs, crawfish, oysters, fuelwood, and other provisioning services. Mangroves store significant amounts of carbon in their soil, and trap sediment, stabilizing coastlines and reducing coastal erosion.

For this analysis, we conducted modeling of coastal protection provided by mangroves using the InVEST model (Tallis and Polasky 2009). The model is based on a combination of global data on human population, wind, and wave energy as well as data specific to Liberia on coastal geomorphology, mangrove habitat, and other variables.

Our results indicate that the most vulnerable coastal areas to erosion are in Bassa, Rivercess, Sinoe, and Grand Kru counties. Coastal protection provided by mangroves is relatively high in Bassa and Rivercess counties, and to a lesser extent in Sinoe county, indicating that these mangroves should be conserved to ensure they continue providing this valuable benefit to people along the coast. In Sinoe county, if environmental conditions are conducive to mangroves, then mangrove restoration or planting might help protect Liberia's coastline where large areas of the coastline are not currently protected by mangroves.

Currently the only protected area that includes mangrove areas is located near Lake Piso. Therefore, most mangroves in Liberia are currently unprotected and may be threatened with loss or conversion in the future. Specifically, the mangroves that may be providing the most benefits in terms of coastal protection, according to our model, are currently unprotected. The modeling results have a high level of uncertainty and should be considered indicative of where mangroves are providing protection to Liberia's coastal population; additional field-based research is needed to validate the results.

Tallis H, Polasky S. 2009. Mapping and valuing ecosystem services as an approach for conservation and natural–resource management. Annals of the New York Academy of Sciences 1162:265–283.



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INTEGRATED MAPS

RACHEL NEUGARTEN

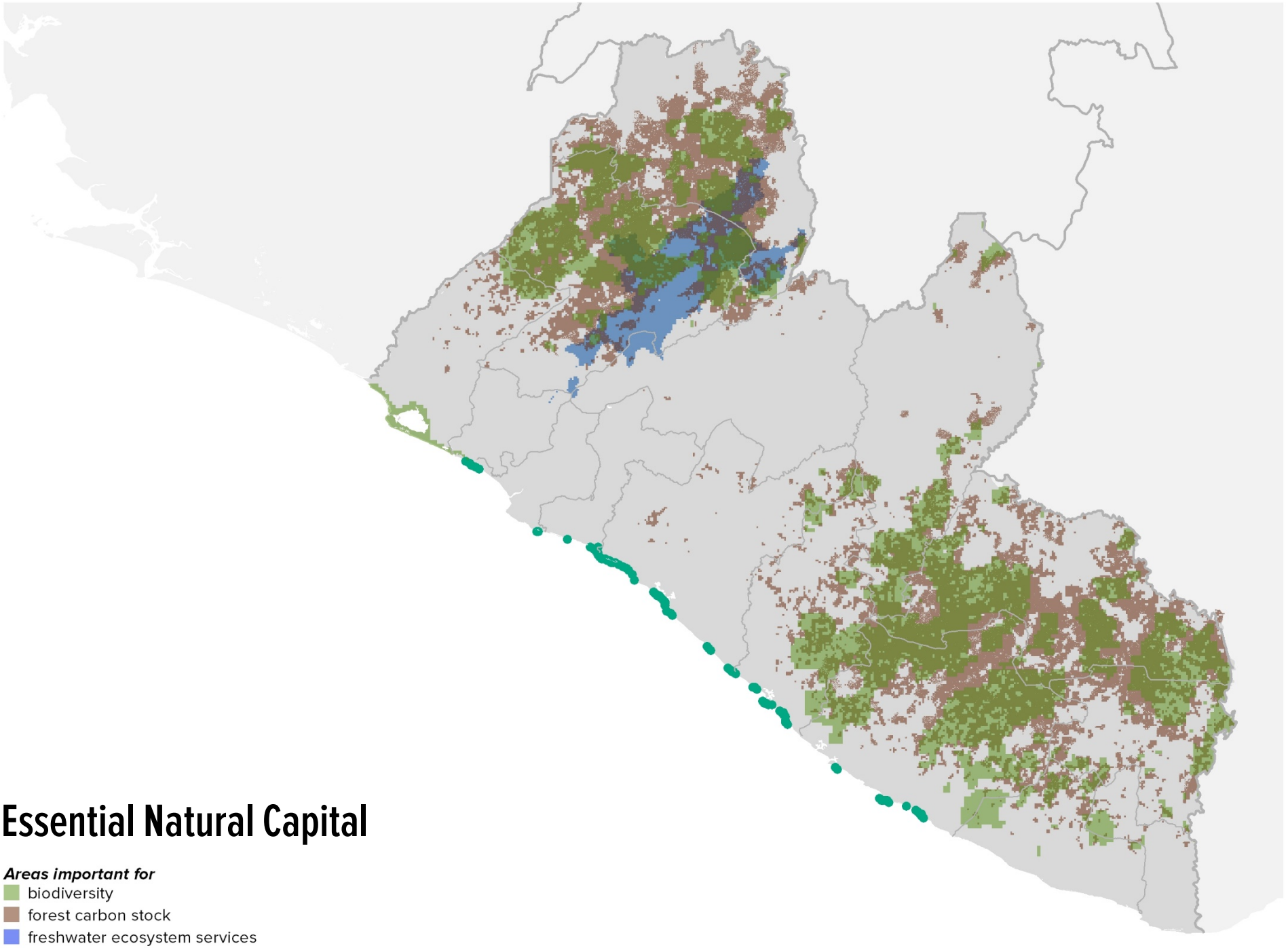
INTEGRATED MAPS: ESSENTIAL NATURAL CAPITAL

We identified the most important areas from each of the maps above. For biodiversity, we directly adopted the existing conservation priority sites (Junker et al. 2015) as "essential natural capital for biodiversity." The FDA has a goal of conserving 30% of Liberia's forest. We used this goal to identify a threshold (233 tC/ha) that would allow us to identify the 30% of Liberia's forest with the highest biomass carbon stocks. For the purposes of this analysis, we define these areas as "essential natural capital for forest carbon." For freshwater, we identified the top 30% of watersheds providing ecosystem services to population centers and existing hydropower facilities. For coastal protection, we identified the top 30% of mangroves that protect Liberia's vulnerable coastal populations. We combined these areas in a single map of "essential natural capital." These areas, which are concentrated in the intact forested landscapes in the northwest and the southeast, should be targeted for conservation, either through protection or through community-based conservation or other measures, as they represent the most essential of Liberia's natural capital.

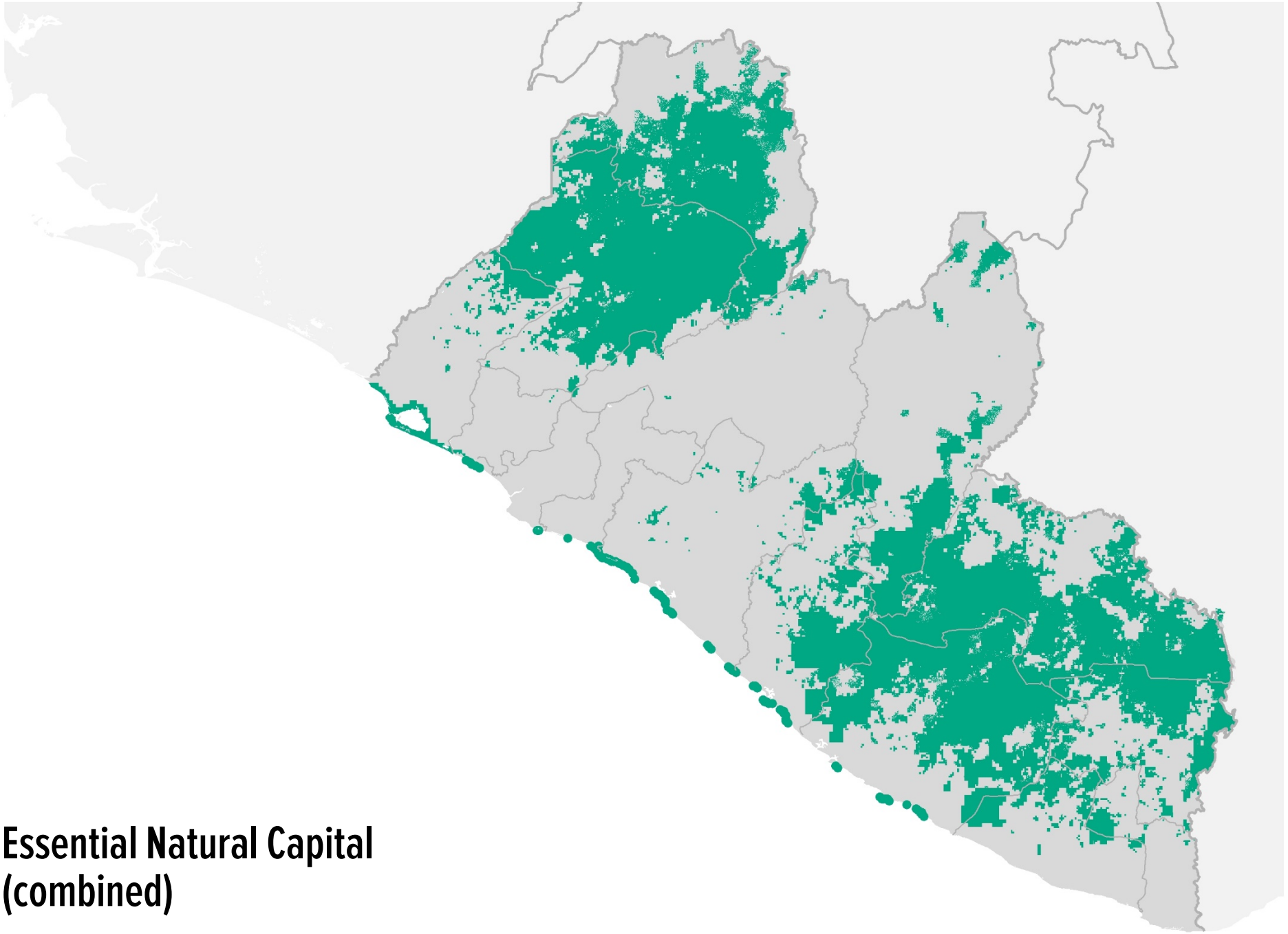
By overlaying the map of essential natural capital with the map of designated and proposed protected areas, we can see that designated protected areas do capture some (7%) of Liberia's essential natural capital, and if proposed protected areas were to be established, they would capture even more (an additional 19%, for a total of 26%). However, 93% of Liberia's essential natural capital is currently unprotected, and the majority (74%) of Liberia's essential natural capital will remain unprotected, even if all proposed protected areas are established.

By overlaying the map of essential natural capital with other data, such as concession areas, vulnerability to tree cover loss, and accessibility to people, we can get a sense of which factors might be threats to Liberia's essential natural capital now and in the future. These maps indicate that Liberia's essential natural capital is not very vulnerable to tree cover loss, and is relatively inaccessible to people – likely because essential natural capital tends to be located in relatively remote areas. This is good news, as it means these areas are probably less threatened with clearing and over-harvesting. The exception are the mangrove ecosystems along the coastline, which are relatively accessible to people. There are, however, some remote areas that are still targeted for hunting, especially for high value species such as primates, which means that they are likely already subject to unsustainable levels of hunting for certain species.

Most of Liberia's rubber and mining concession areas do not overlap with Liberia's essential natural capital. Some palm oil concessions, however, particularly in the north, do overlap with some areas of essential natural capital. Timber concessions by and large also overlap with Liberia's essential natural capital. Special attention should be paid to these areas to ensure they are sustainably managed. A multitude of management strategies such as community forestry, Payments for Ecosystem Services (PES) schemes, REDD+, or other creative solutions are needed to ensure the flow of benefits from natural capital is sustained.



Conservation International 2017.
Mangrove extent exaggerated for visibility at this scale

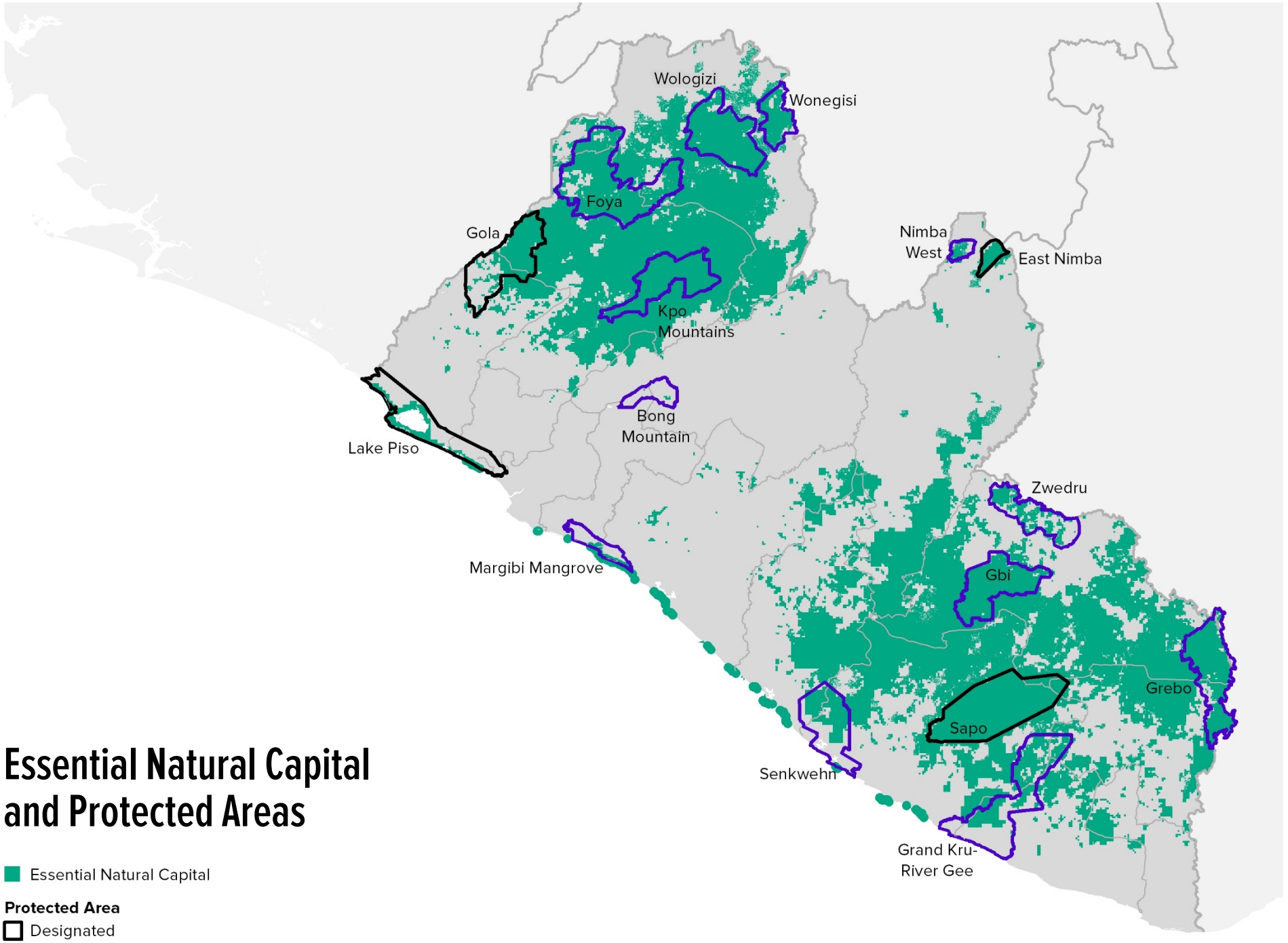


Essential Natural Capital (combined)

Essential Natural Capital

50 km

Conservation International 2017.
Mangrove extent exaggerated for visibility at this scale



Essential Natural Capital and Protected Areas

Essential Natural Capital

Protected Area

Designated

Proposed

Conservation International 2017.
Mangrove extent exaggerated for visibility at this scale

ESSENTIAL NATURAL CAPITAL & PROTECTED AREAS

Table 5. Essential natural capital within designated and proposed protected areas

Category	Area (km^2)	Percentage
Essential Natural Capital (designated protected areas)	2545.5	7%
Essential Natural Capital (proposed protected areas)	6652.9	19%
Essential Natural Capital (unprotected)	26761.3	74%
Total Essential Natural Capital	35959.7	100%

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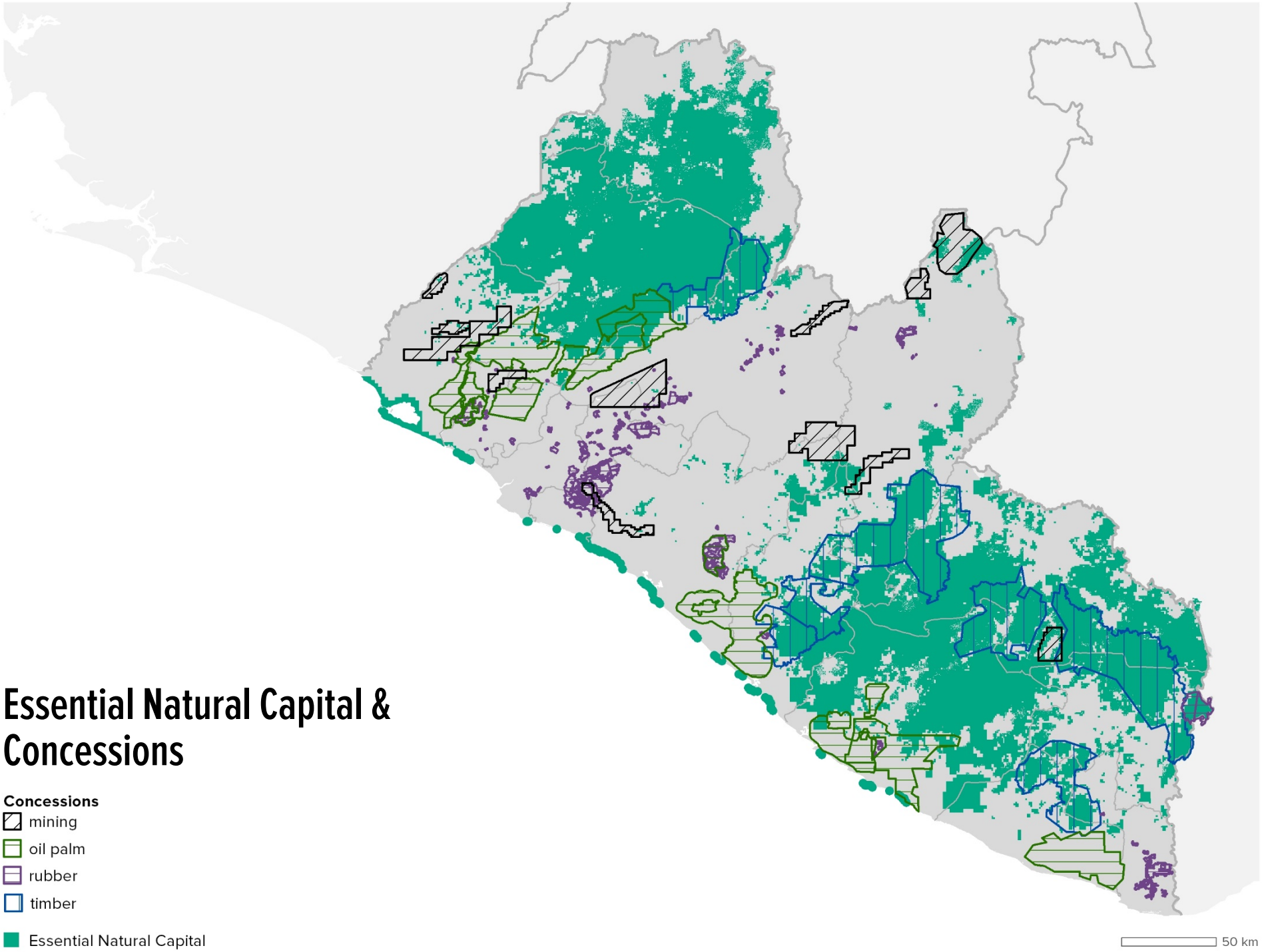
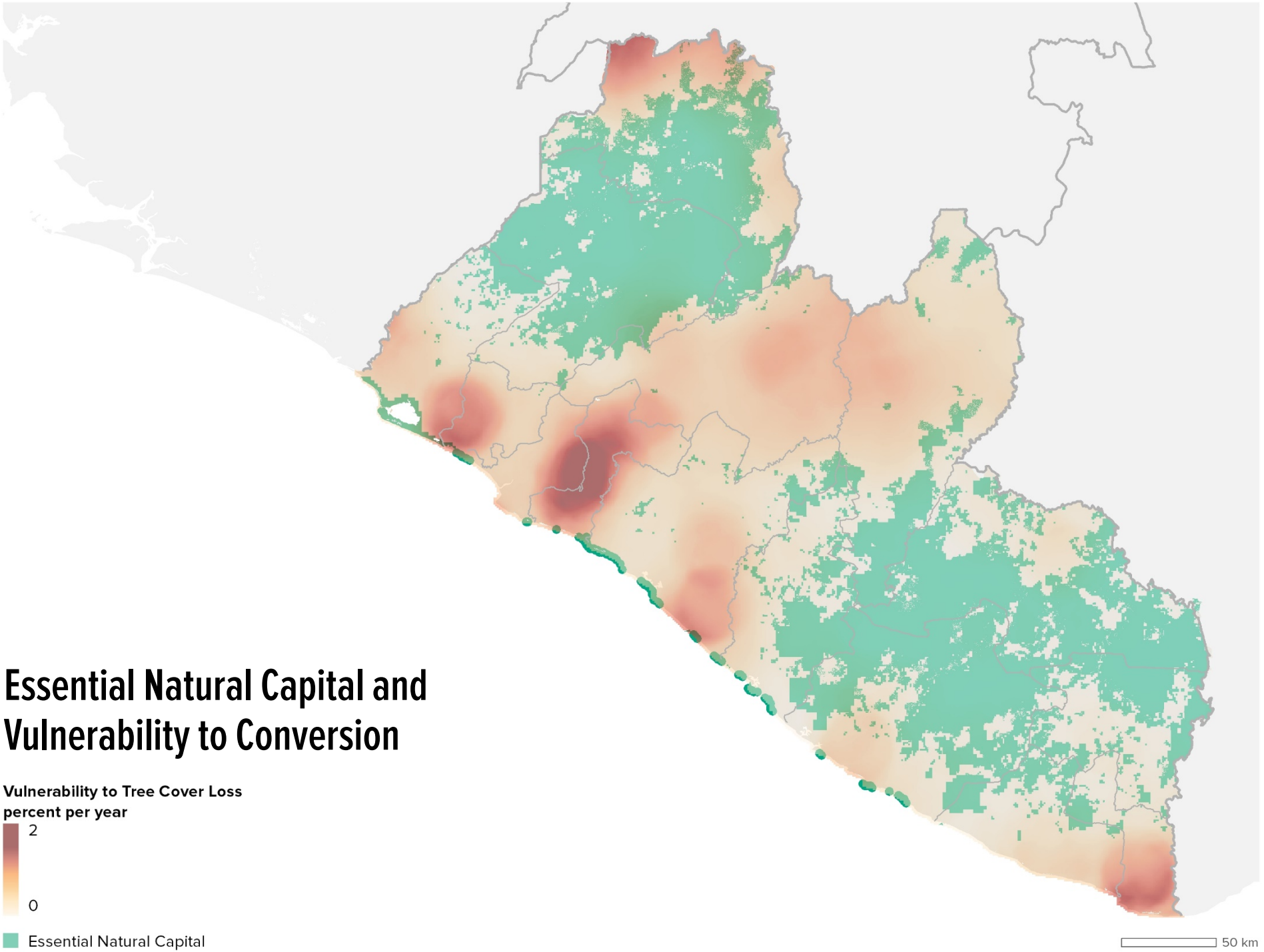
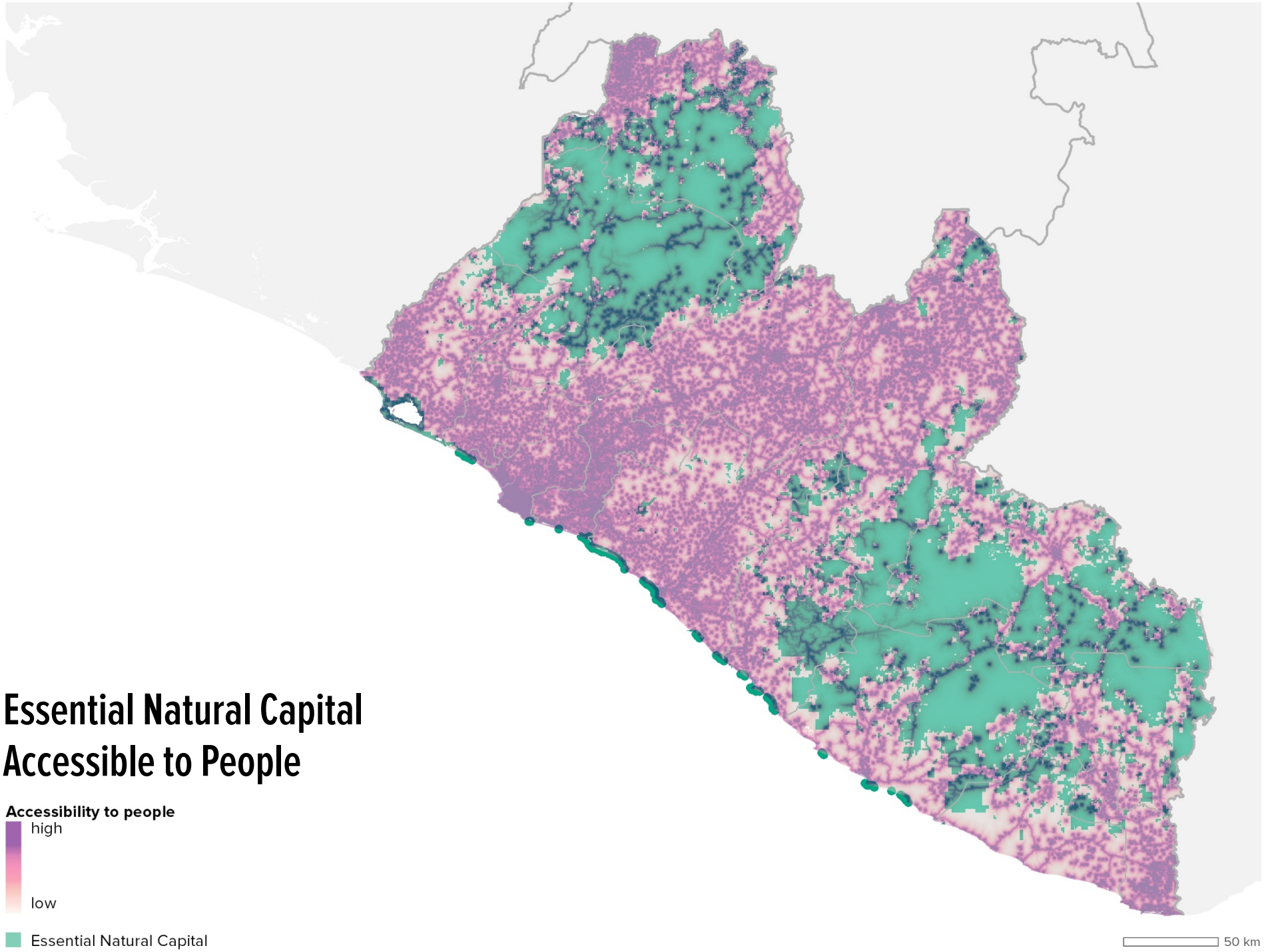


Conservation International 2017.
LISGIS (Liberia Institute of Statistics and Geo-Information Services.)



Conservation International 2017.
Mangrove extent exaggerated for visibility at this scale



Conservation International 2017.
Mangrove extent exaggerated for visibility at this scale

INSIGHTS

7% OF ESSENTIAL NATURAL CAPITAL IN LIBERIA IS WITHIN DESIGNATED PROTECTED AREAS

A TOTAL OF 26% WOULD BE PROTECTED IF ALL PROPOSED PROTECTED AREAS WERE DESIGNATED

HOWEVER, 58% OF ESSENTIAL NATURAL CAPITAL IN LIBERIA FALLS WITHIN CONCESSIONS

Data sources

All maps produced by Conservation International 2017. For complete methods and references see: Conservation International 2017. Natural Capital Mapping and Accounting in Liberia: Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development.

Selected data sources:

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Coastal Vulnerability & Protection from Mangroves

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Palm Oil, Rubber, Timber, Mining

- LISGIS (Liberia Institute of Statistics and Geo-Information Services.)

LIBERIA: MAPPING NATURAL CAPITAL

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