Recommended Practices for the Responsible Siting and Design of Solar Development in Georgia

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This document is intended to provide voluntary guidance to support consideration of natural resources during the development of photovoltaic solar in Georgia. Relevant regulatory requirements are also provided, but this guidance ***does not supersede any consultation or regulatory requirements****. The Georgia Department of Natural Resources and the U.S. Fish and Wildlife Service would like to acknowledge the Georgia Utility Scale Solar Siting Initiative Partnership in this effort. This partnership was organized by Georgia Wildlife Federation. Development of the guidance document was coordinated by The Nature Conservancy. Additional partners include Georgia Conservancy, Georgia Power Company, Green Power EMC, National Wild Turkey Federation, The Orianne Society, Quail Forever, Tall Timbers Research Station and Land Conservancy, the Turner Foundation, and others.*

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Introduction

The acceleration of solar energy development in the United States is crucial to meet the nation's growing demand for clean renewable energy. Georgia, much like the rest of the world, is experiencing two intertwined challenges – climate change and the rapid loss of biodiversity. Renewable energy development can support local economies and serves an important role in mitigating climate change impacts experienced by wildlife, other natural resources and communities. Technological advances and declining costs have made solar a very economical form of new energy generation. Like many other sunny states, Georgia is well-suited for photovoltaic (PV) solar development, and the pace of development is increasing due to the demand for renewable energy from companies and consumers. In 2023, the Solar Energy Industry Association (SEIA) ranked Georgia 7th for total installed solar capacity.[1]

Large-scale solar energy development can provide a range of economic benefits to communities through revenue, jobs, and workforce development. Additionally, the Department of Energy found that 80% of new PV solar energy must come from large, utility-scale solar installations in order to achieve 100% decarbonization by 2050.[2] However, these large PV solar installations, or solar "farms," require developing a significant quantity of land relative to traditional forms of energy, often 5-7.5 acres for every megawatt of generated energy.[3] By 2050, an estimated 7.5 to 10 million acres of land nationwide will be converted to PV solar energy.[4] With projected land conversion at this scale, appropriate siting, construction practices, and maintenance procedures of solar facilities are critical to grow PV solar resources sustainably while also protecting and enhancing natural resources, biodiversity, and ecosystems. Through proactive planning and partnership, PV solar development can help meet Georgia's renewable energy needs, minimize impacts to natural resources, and maximize opportunities to provide co-benefits to the local environments of Georgia.

Georgia is a very geologically diverse state, with six level III ecoregions[5], each with its own characteristics and challenges. As solar development in Georgia continues to expand state-wide, the natural resource constraints and opportunities for a PV solar development project will vary based on the unique considerations in each geography. Awareness about a project's ecoregion will help to identify the most likely ecological challenges for a particular project. Navigating from northwest to southeast, Georgia's ecoregions include Southwestern Appalachians, Ridge and Valley, Blue Ridge, Piedmont, Southeastern Plains, and the Southern Coastal Plain.

[1] https://www.seia.org/state-solar-policy/georgia-solar
[2] https://www.energy.gov/eere/solar/solar-futures-study
[3] https://www.nrel.gov/docs/fy13osti/56290.pdf
[4] https://www.energy.gov/eere/solar/solar-futures-study
[5] https://www.epa.gov/eco-research

U.S. Geological Survey: Map of Georgia Ecological Regions, South Atlantic Water Science Center 2023

This document provides voluntary guidance on a range of recommended management practices (RMPs) for PV solar facility developers to consider that can help maximize opportunities to develop PV solar facilities in a sustainable way for the ecosystems and wildlife of Georgia. This document is focused on natural resource guidance for all steps of the PV solar facility process, from site selection to construction to operation and maintenance. Each project has unique siting and design constraints and opportunities, so not every recommendation will be suitable or feasible for every PV solar project in Georgia. The guidance provided is intended to be used as a reference and does not supersede any consultation or regulatory requirements. We welcome feedback (which can be sent to gasolarsiting@gwf.org) and will seek to regularly update this guidance as new information and improved practices are identified.

Suggested citation

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Site selection

Solar energy production is a fast-growing renewable energy source that has lower greenhouse gas emissions compared to conventional energy sources (coal, oil, gas, etc.). There are important natural resource considerations for planning, development, and maintenance of solar facilities. Proactive analysis of potential locations for large solar facilities can avoid unnecessary impacts to the environment and enable mitigation planning for unavoidable impacts. Avoiding areas known to be important for biodiversity and wildlife species of concern can also prevent project delays and help foster long-term co-existence of solar energy and natural resources. For reference, Georgia defines "wildlife" as "*any vertebrate or invertebrate animal life indigenous to this state or any species introduced or specified by the board...*".

To support this long-term co-existence, the proactive use of previously developed or disturbed sites should be prioritized whenever possible. Existing disturbed surfaces such as landfills, surface mines, some warehouse rooftops, decommissioned industrial sites, and large parking lots may be well suited for solar power generation at variable scales. While not always feasible for large-scale generation, development of these sites for solar production does not require further habitat conversion, fragmentation, or degradation. However, challenges exist with developing industrial sites such as brownfields[6] for solar due to the additional environmental risk and environmental site assessment, additional permitting, remediation, size constraints, and special site preparation and construction practices. Previously developed or disturbed sites may also have large cost differentials for solar development but may also qualify for certain financial incentives. Investments in clean energy such as the Infrastructure Investments and Jobs Act (IIJA)[7] and the Inflation Reduction Act (IRA)[8] increase funding for clean energy development with targeted support for energy projects in "energy communities" which include communities with brownfields, abandoned coal mines, coal-fired electric power plants, or significant economic involvement in conventional energy source extraction, processing, transport, or storage.[9]

Species and Ecosystems of Conservation Concern

The southeastern United States is one of the most biodiverse areas of the country, and Georgia's terrestrial and aquatic species represent a significant portion. Areas that are likely to have high biodiversity include freshwater rivers, streams, and wetlands throughout the state, sandhill habitats, forested areas, and coastal marshes and ecosystems.[10] For example, sandhill habitats throughout the Southeastern Plains and Southern Coastal Plain may appear less productive, but they contain significant biodiversity and are crucial habitat for declining species of conservation concern in Georgia. They provide habitat for the gopher tortoise (which is the state reptile of Georgia and a state-protected species), the federally listed eastern indigo snake and red-cockaded woodpecker, gopher frog, Bachman's sparrow, pocket gophers, and others. Forests and forestry are very important to Georgia, with more than 60% of Georgia being forested. Forested sites like the rich, mesic, slope and cove hardwood forests in the Piedmont and Blue Ridge ecoregions provide habitat for many important game and non-game species, support air and water quality, and help store carbon in their soils and their

[6] https://cleanpower.org/wp-content/uploads/2022/08/ACP_FactSheet_Brownfields_220830.pdf
[7] https://www.whitehouse.gov/build/guidebook/
[8] https://www.whitehouse.gov/cleanenergy/inflation-reduction-act-guidebook/
[9] U.S. Department of Energy's Energy Community Tax Credit Bonus web mapping tool: https://arcgis.netl.doe.gov/portal/apps/experiencebuilder/experience/?id=a2ce47d4721a477a8701bd0e08495e1d
[10] https://georgiawildlife.com/sites/default/files/wrd/pdf/swap/HighPriorityHabitats_ExcerptGaSWAP2015.pdf

vegetation. Georgia ranks among the top five states in the United States for diversity of aquatic species but also ranks among the top states for imperiled freshwater aquatic species. Site selection that considers and proactively avoids, minimizes, or mitigates impacts to high priority habitats[11] can protect not only the sensitive species that rely on these habitats, but also protect the ecosystem services that these resources provide, such as clean water, clean air, carbon sequestration, and recreation. These ecosystem services are vital to the well-being of the local community as well as the local wildlife.

Connectivity

Habitat loss and fragmentation is one of the greatest challenges to the state's natural resources. Species rely on the availability of suitable habitat throughout their lifecycle for resources like food, shelter, and water, and fragmented habitats make it harder for populations to locate the resources they need to thrive. Management of reduced or fragmented systems, such as forests, may become more challenging at a landscape scale, which can contribute to declines in the overall health of the system as well. Solar installations can contribute to habitat fragmentation when not sited or designed with connectivity in mind. Therefore, it is recommended to minimize or avoid siting solar facilities in locations that contribute to large-scale habitat fragmentation. GA Department of Natural Resources (DNR) recommends trying to avoid siting projects directly adjacent to lands identified as permanently protected in the state's Conservation Lands database or in priority corridors as identified in the State Wildlife Action Plan (SWAP).[12] However, when these adjacent areas are also facing development pressure from more impactful and irreversible land uses, solar development may be the less impactful option, especially if additional conservation practices are incorporated. In situations where projects cannot avoid being sited next to conservation lands or when solar may a less impactful development option, developers should communicate this with the appropriate state agency or land manager as soon as possible to ensure alignment before the project progresses.

Streams and Wetlands

Streams and wetlands provide essential habitat and resources for a variety of imperiled species, and they also provide freshwater resources, erosion and flood control, groundwater recharge, and recreational opportunities for communities. Georgia has 70,150 miles of streams and rivers, over 425,000 acres of lakes, and over 4,500,000 acres of freshwater wetlands. Georgia's abundant water supplies provide drinking water; recreational areas ideal for swimming, fishing, and boating; and water for generating hydroelectric power.[13] Direct as well as indirect impacts to these resources may not only impact sensitive species but can also decrease water quality and availability as well as increase operational challenges, delays, or fines. A site's potential for stormwater impacts to streams and wetlands, during both the construction of the facility and later during operation, derives from physical characteristics such as the site's prior land use, soil, and geology as well as the amount, duration, and method of land disturbance during a given phase of construction. Review of the soil characteristics for a particular site can reveal potential risks that should be considered during site selection. Areas with hydric soils can flood or pond, thereby limiting access to facilities and hindering maintenance. Areas with steep slopes, colloidal clay soils or highly erodible soils are at a higher risk for erosion, sedimentation, and runoff. Soils with high percentages of fine sands and silts are common within the Piedmont ecoregion, often resulting in greater potential impacts to wetland or stream systems from

[11] https://georgiawildlife.com/sites/default/files/wrd/pdf/swap/HighPriorityHabitats_ExcerptGaSWAP2015.pdf
[12] 2015 SWAP: Appendix N, Page N-19: https://georgiawildlife.com/sites/default/files/wrd/pdf/swap/appendix-n-ecosystems-habitat-mapping-technical-team-report.pdf
[13] https://gadnr.org/resources

stormwater runoff. Avoidance of sites with these soil characteristics is recommended when possible, and if it is not possible, additional measures should be taken during site design, construction, and operation to stabilize the site, minimize erosion, and avoid stormwater impacts.

The large size of PV solar developments often results in significant land disturbance, which can have a greater impact on water quality in the surrounding area. Successful stormwater management systems during construction and for the duration of a solar facility's operation can reduce sedimentation, reduce impacts to the natural hydrograph, and reduce chemical inputs into aquatic systems. Coverage under the National Pollutant Discharge Elimination System Stormwater Discharges Associated With Construction Activity Permit is **required** for any construction project that disturbs one (1) acre or more in the state of Georgia. To obtain permit coverage in line with the standard National Pollutant Discharge Elimination System Stormwater Discharges Associated With Construction Activity For Stand Alone Construction Projects Permit GAR100001 (NPDES Permit), the Georgia Department of Environmental Protection (GA EPD) currently requires additional review for sites that disturb more than fifty (50) acres contiguously. This review is designed to ensure projects limit disturbance when possible and incorporate necessary best management practices when not possible. During this review, developers will be asked by GA EPD to provide a technical justification of why more than fifty (50) acres is necessary to be disturbed contiguously, the total planned acres of disturbance, the owner's compliance status with GA EPD, soil types, topography, identification of all state waters on and within 200 feet of the project boundaries, any impaired stream segments on or within one (1) linear mile upstream of and within the same watershed of an impaired stream segment for certain impairments[14], and the site proximity to sensitive areas such as wetlands, drinking water intakes, marshes or trout streams. The results of this review may trigger requirements for increased buffers on state waters, twice the sediment storage and seventy (70) percent more post construction stormwater retention. This may also require that the construction project be broken into segments or phases. Official guidance for the fifty-acre approval process can be found here.[15] For more information or to ask general questions please contact the county GA EPD District Office.[16]

When site disturbance is anticipated in proximity to suspected wetland or stream resources, it is recommended to proactively consider the voluntary use of native vegetative buffers that are larger than minimal requirements to avoid unnecessary impacts. For example, 50 ft. buffers along intermittent streams and ephemeral wetlands or 100 ft. along perennial streams and wetlands is suggested in Georgia Forestry Commission's Best Management Practices for Forestry.[17] Site design and planning should avoid the placement of access roads across streams or wetlands whenever possible. Direct impacts to jurisdictional wetlands will also require permitting and should be avoided whenever possible. The distribution of solar arrays on the landscape relative to nearby wetlands should be considered since ecosystem functions that wetlands provide may be diminished if the areas near the wetlands are developed. Additionally, the disturbance that results from construction can also interfere with the ability of nearby wildlife to utilize the wetlands, which may decrease or fragment their available habitat. Developers are advised to avoid surrounding a wetland area with solar arrays whenever possible.

[14] http://epd.georgia.gov/georgia-305b303d-list-documents

[15] https://epd.georgia.gov/forms-permits/watershed-protection-branch-forms-permits/storm-water-forms/npdes-construction

[16] https://epd.georgia.gov/about-us/epd-district-offices

[17] Georgia Forestry Commission 2019: https://gatrees.org/forest-management-conservation/water-quality-protection/

Agricultural Lands

Agricultural lands are often chosen as solar sites, and there are potential benefits to utilizing idle or lower-production agricultural lands for solar rather than active and productive agricultural sites. However, the removal of prime farmland from agricultural production is a concern.[18] American Farmland Trust reports that as much as 83 percent of new solar facilities will be built on agricultural lands with nearly half of those constructed on the most productive farmlands. Prime farmland is defined by the U.S. Department of Agriculture (USDA) as lands which are most suited for producing food, feed, fiber, and oilseed crops. The USDA's Farmland Protection Policy Act (FPPA) seeks to "minimize the impact Federal programs have on the unnecessary and irreversible conversion of important farmland to non-agricultural uses".[19] If the solar site contains designated "important" farmland and uses Federal funding sources, the federal funding agency is required to submit an FPPA evaluation to the Natural Resource Conservation Service (NRCS)[20] to determine if the land use change is considered "irreversible." If the funding is not Federal, consideration of alternative sites should still occur if the primary site contains significant Prime farmland or Farmland of Statewide Importance.

Idle or lower-production agricultural lands are previously disturbed and do not typically support significant native plant or animal communities relative to undisturbed natural sites, so use of these lands can result in less impactful and more economical site preparation compared to undisturbed vegetated sites. When properly considered, conversion of low-production agricultural lands to solar installations may improve water availability and water flow for the local community and nearby wildlife. Less productive agricultural lands often require additional irrigation and fertilizer investments to maintain successful production, so conversion away from agricultural practices on all or a portion of the land decreases the water and fertilizer use on site, which can contribute to improved water flow and quality. Solar leases can also provide economic stability for farmers facing an uncertain future without having to sell their land. There are also growing opportunities for farmers interested in PV solar on their land to combine agricultural practices (e.g., crop production, grazing, and beekeeping) within the footprint of PV solar farms.[21] For example, various PV solar facilities in Georgia are grazing sheep, growing crops (tomatoes and lettuce), and producing honey.[22] For more information, see the Enhance Agricultural Opportunities section of this guidance. Additionally, agricultural sites leased for solar may successfully be returned to agricultural use afterward if appropriate considerations are incorporated throughout all phases of a PV project. Avoiding soil compaction, soil erosion, and degradation of soil health while maintaining water quality through adherence to best practices are essential for protecting a site's viability for future agricultural uses.

Local Engagement and Cultural Resources

As soon as it is possible to do so, it is recommended that solar developers meet with local planning officials early in the process (and well in advance of submitting a formal application) to help identify local community planning requirements, community siting guidance, natural and cultural resources of

[18] American Farmland Trust (February 2024): Recommendations for State and Local Governments to Advance Smart Solar Policy. https://farmland.org/wp-content/uploads/2023/12/AFT-Recommendations_for_State_and_Local_Governments_to_Advance_Smart_Solar_Policy.pdf

[19] https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/land/cropland/farmland-protection-policy-act

[20] https://www.nrcs.usda.gov/conservation-basics/conservation-by-state/georgia#contact

[21] https://www.osti.gov/biblio/1882930

[22] https://openei.org/wiki/InSPIRE/Agrivoltaics_Map

local significance, and public meeting and communications requirements. A review of any available Future Land Use maps, comprehensive plans, historic maps, and existing zoning regulations can help developers determine whether the proposed solar installation aligns with the community's future vision and historic or cultural resources. Local and regional Land Trust[23] and Riverkeeper[24] organizations familiar with a particular geography can support early conversations around potential hurdles and challenges earlier in the planning process to avoid unexpected project delays. Early coordination with local planning officials will increase the timely review of a project and can improve early identification of project conditions that may need to be incorporated in order to secure local project approval.

Desktop Resources

Early coordination with the U.S. Fish and Wildlife Service (USFWS), state agencies such as the GA DNR/GA EPD, and local city/county officials is strongly recommended for site-specific reviews, recommendations, and requirements. During site selection, all practicable efforts should be made to avoid and minimize impacts to state and federally listed threatened and endangered species, state priority species, and habitat that is important for these species. See the Focal species of concern section of this document for additional information on species of particular concern. To help with site selection and early impact analysis, a variety of resources are available for preliminary desktop analysis, keeping in mind that desktop analysis is not a substitute for field assessment:

- **Federal species of concern**: Coordination with the USFWS should occur in the early planning stages to determine the potential for impacts to federally listed species or at-risk species (ARS). Contacting USFWS is recommended if federally listed species may be affected by the activity. The process to contact Georgia-based USFWS staff for project reviews is outlined on the Georgia Ecological Services website.[25] Preliminary species lists for federally listed species near a project area can be obtained through the USFWS IPaC system,[26] and an official species list should be generated prior to contacting USFWS with project-specific technical assistance requests as the official list will also provide additional guidance. Information about ARS can be found through the USFWS listing workplan found on the USFWS Southeast At-Risk Species Finder.[27] Depending on the initial site information during coordination, the USFWS may recommend surveys be conducted for potential federally listed species as well as ARS or species under review for federal listing. It is possible that some of the ARS may be listed under the Endangered Species Act (ESA) during the solar facility's construction or operational life and impact the continued development or maintenance of a facility.
- **State species and natural communities of concern**: Seek to avoid impacts to species and natural communities of conservation concern in Georgia, which are outlined in the State Wildlife Action Plan.[28] Information on state species of concern is available here.[29] For more information on contacting GA DNR for project assistance regarding species or communities of conservation concern, review the process here.[30]

[23] https://landtrustalliance.org/land-trusts or Association of Georgia Land Trusts (AGLT): https://www.georgiaconservancy.org/aglt

[24] Georgia River Network. River Groups and Resources: https://garivers.org/discover-a-local-river-group/

[25] USFWS Project Planning and Review: https://www.fws.gov/office/georgia-ecological-services/project-planning-review

[26] USFWS Information for Planning and Consultation: https://ipac.ecosphere.fws.gov/

[27] USFWS Southeast At-Risk Species Finder: https://experience.arcgis.com/experience/c578e0f4d7ab48a7a9648abe76296ec4?org=fws

[28] https://georgiawildlife.com/WildlifeActionPlan

[29] https://georgiabiodiversity.org/portal/

[30] GA DNR Environmental Review: overview provided at https://georgiawildlife.com/environmental-review or contact Nongame.Review@dnr.ga.gov for additional information.

- **Floodplains and wetlands:** Utilize data provided by the USFWS National Wetland Inventory (NWI) mapper[31] to consider proximity to these habitats and land characteristics. It is recommended to connect with the local floodplain coordinator if floodplain impacts are suspected, even if no federal floodplains are indicated on the NWI mapper.
- **Soils**: The NRCS Web Soil Survey[32] can be utilized to assist in identifying Prime farmland or farmland of statewide importance as well as soils that contain colloidal clay or are highly sloped, erodible, or hydric.
- **Overall planning for lower impact site selection**: The Georgia Low Impact Solar Siting Tool (GA LISST[33]) was developed by the Nature Conservancy in partnership with USFWS, GA DNR, and others to support proactive siting of solar in areas with lower environmental impact. Information is provided through the WebMap application, and the environmental sensitivity rankings can also be visualized within the USFWS IPaC system.
- **Cultural resources**: A desktop review for cultural resources should conform to the *Georgia Standards and Guidelines for Archaeological Investigations* (2019)[34] and may include a review of the Georgia Natural, Archaeological, and Historic Resources Geographic Information System database,[35] the National Register of Historic Places,[36] Find-A-Grave,[37] or other resources. Further coordination with the Georgia Department of Natural Resources State Archaeologist[38] is encouraged.

Summary of Site Selection Considerations
• **Prioritize siting on previously disturbed or degraded lands whenever possible. Avoid conversion of forested and sandhill habitats that provide important ecosystem services such as flood and stormwater mitigation, groundwater recharge, erosion and sedimentation controls, carbon sequestration, nutrient management in addition to potential habitat for endangered, threatened, and other species of concern.**
• **To minimize habitat fragmentation and support conservation corridors, avoid siting adjacent to lands that are already conserved for biodiversity or that provide connectivity between such protected lands or priority corridors.**
• **Identify stream and wetland resources on or near the site and develop plans to avoid and minimize impacts whenever possible. For sites with possible impacts to nearby streams or wetlands, plan for the required vegetative buffers and consider increasing the buffers around these resources when feasible.**
• **If significant land clearing will be required or if a site contains highly erodible or steeply sloped soils, anticipate and plan for a higher stormwater runoff potential.**

[31] USFWS National Wetland Inventory (NWI): https://www.fws.gov/program/national-wetlands-inventory
[32] NRCS Web Soil Survey: https://websoilsurvey.nrcs.usda.gov/
[33] Georgia Low Impact Solar Siting Tool: https://galowimpactsolar.tnc.org/
[34] Georgia Council of Professional Archaeologists. 2019. http://georgia-archaeology.org/GCPA/wp-content/uploads/2020/03/FINAL-Georgia-Standards-and-Guidelines-for-Archaeological-Investigations-12-19-2019.pdf
[35] https://www.gnahrgis.org/
[36] https://www.nps.gov/subjects/nationalregister/database-research.htm
[37] https://www.findagrave.com/
[38] Georgia Office of the State Archaeologist: https://gadnr.org/Archaeology/DNRService

• **Avoid conversion of highly productive agricultural lands. If agricultural areas are being considered, prioritize siting on lands that are idle, lower production, or those that currently require significant irrigation.**
• **Engage the local planning department as well as Land Trust or Riverkeeper organizations early to understand unique local challenges and priorities that may need to inform planning for site development and construction.**
• **Utilize available agency expertise and desktop resources earlier during site selection to avoid or minimize resource impacts to the extent practicable.**

Site design

Once a site has been selected for development, the design of the solar facility has significant influence on the overall impact. Considerations such as design of fencing, panel height and spacing, site preparation, and vegetation management can all contribute to improved outcomes for wildlife by minimizing impacts and enhancing co-benefits of the solar facility. Although the footprint of utility-scale PV solar facilities often occupies large areas, the associated infrastructure does not completely consume the footprint. There may be opportunities for leaving existing vegetation or implementing dual-use strategies within the footprint, such as establishing native plant species or co-locating agricultural activities ("agrivoltaics"). This section provides suggestions on ways to reduce barriers to wildlife movement, minimize impacts to watersheds, provide on-site habitat, increase engagement with local communities, and enhance agricultural opportunities.

Reduce Barriers to Wildlife Movement

Landscape permeability is an often-cited concern with PV solar development, largely due to perimeter fencing excluding wildlife from the footprint and unknown impacts to the movement of larger species.[39,40] In Georgia, wildlife connectivity and movement may be of greatest concern when PV solar facilities are sited within or near intact habitats. An effective method for allowing movement of both large and small animals at large solar installations (>50 acres) is to retain unfenced wildlife passageways between fenced solar installations. For example, solar developers typically avoid development near rivers, streams and their associated riparian areas and wetlands, and these areas can then also serve as wildlife passageways. Another approach on sites that are not low-lying is to consider providing wildlife passages (for example, an 8" diameter HDPE pipe) around the site.

For security and public safety reasons, all PV solar facilities are required by the National Electrical Safety Codes to have perimeter fencing that is at least 7 feet high. However, fence modifications like incorporation of wildlife-friendly fencing can occur at the local level through coordination with the Authority Having Jurisdiction (AHJ) that are responsible for enforcing building codes, fire codes, and other regulations. Various forms of wildlife-friendly fencing have been deployed at PV facilities with success, allowing access for a variety of small to medium non-flying wildlife (e.g., foxes and rabbits).

[39] Cypher, B. et al (2021). Photovoltaic solar farms in California: can we have renewable electricity and our species, too?. *California Fish and Wildlife* 107(3):231-248. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=195581&inline

[40] Leskova, O., Frakes, R., and Markwith, S. (2022). Impacting habitat connectivity of the endangered Florida panther for the transition to utility-scale solar energy. Journal of Applied Ecology 59(3):822-834. https://doi.org/10.1111/1365-2664.14098

Partnerships in North Carolina[41] have found success using 6 ft. tall deer mesh (17/75/6, 12.5 gauge) installed upside-down to provide a 7-inch vertical space at the bottom for passage. When implementing wildlife-permeable fences, equally important is providing on-site vegetation that provides cover for animals when moving through the site. While addressing safety and security takes priority in fencing design, designers are encouraged to consider fencing modifications that accommodate wildlife movement and connectivity when it is appropriate to do so, given local species of concern and their habitats.

Minimize Watershed Impacts

Panel design considerations (including height, spacing, and choice of racking and mounting systems) determine the productivity of the site in terms of the quantity and reliability of energy produced, and these considerations can also impact groundwater infiltration and runoff as well as feasibility of co-located agricultural uses. Incremental increases in space between panel arrays or inclusion of adaptable tracker systems can increase water infiltration opportunities during rain events, especially when the site has sufficient vegetated cover. This can improve groundwater recharge (which is especially important in areas with lower groundwater availability) and decrease the risk of stormwater runoff and erosion and sedimentation impacts on water quality. The PV-SMaRT research found that runoff increased by 14% when array spacing was increased from 15 feet to 35 feet.[42] However, increased spacing can also increase the overall site footprint, which is not always preferrable or feasible depending on other siting and design considerations. Therefore, an overall review of the site's unique biodiversity and hydrology will be necessary to determine the most impactful conservation design practices for a particular site.

Special care should be taken during site design if streams or wetlands are on or near a site. Whenever feasible, maintain undisturbed vegetative buffers around these features to reduce impacts to nearby wildlife as well as aquatic habitat both within and downstream of the site. These buffers may act as a travel corridor for wildlife, and forested riparian buffers protect water quality by stabilizing stream banks and filtering storm water runoff. It is recommended to configure a site to avoid disturbance to wetlands or stream areas. If impacts are unavoidable or if stream crossings or culverts are needed, consult with the U.S. Army Corps of Engineers (USACE) – Savannah or Mobile districts and the GA EPD to determine if a permit and mitigation is required for activities impacting these areas. In-stream structures, such as low flow crossings, bridge footings, and culverts, can interrupt the natural stream bed, create barriers to fish passage, and cause sedimentation. More information on recommended practices to avoid these impacts is available in the stream crossing handbook of Georgia.[43]

Provide On-Site Habitat

Plans for vegetation management can influence components of the site design, so it is recommended that these decisions be made in conjunction with the site design process. Avoiding unnecessary vegetation clearing and soil grading or other soil disturbances during the pre-construction process can minimize impacts to wildlife and their habitats, reduce erosion potential, improve groundwater recharge, and limit impacts to already sequestered carbon and other soil nutrients. Unnecessary clearing of vegetation, especially on sloped or erosional soils, will often require stronger sedimentation and

[41] The Nature Conservancy in North Carolina: https://www.nature.org/en-us/about-us/where-we-work/united-states/north-carolina/stories-in-north-carolina/making-solar-wildlife-friendly/

[42] Great Plains Institute. 2023. Best Practices: Photovoltaic Stormwater Management Research and Testing (PV-SMaRT): https://betterenergy.org/wp-content/uploads/2023/01/PV-SMaRT-Best-Practice.pdf

[43] Georgia Aquatic Connectivity Team. (2021). Stream Crossings in Georgia: A Handbook for Connectivity and Resilience: https://ga-act.org/Publications/stream-crossing-handbook2021.pdf

erosion protocols throughout project construction and will also increase replanting costs. For areas that do require clearing, some developers in Georgia have found that pre-stabilizing the site through planting of preferred seed mixes prior to construction can often decrease costs and maintenance requirements compared to replanting of bare soils after construction.

Incorporation of low-growing native plantings or ecoregion-specific seed mixes throughout all or a portion of a site can decrease maintenance costs (after plants are established) while also providing important habitat and other benefits.[44] The more diverse the native seed mix, the greater the potential benefit for a wider range of insects and other pollinators as well as nearby wildlife. For example, more structurally diverse vegetation provides a wider variety of onsite resources such as food, refugia, and nest sites throughout the year.[45] Native plantings may also support the efficiency of solar panels by reducing the ambient air temperature and creating a cooler microclimate.[46] Native seed mixes that are the most appropriate for a particular ecotype or location may currently be more expensive or more limited in availability than other seed mixes, which often contain noxious or non-native species. However, the higher initial cost of native seed mixes may be offset by reduced mowing frequency and greater long-term survival and water retention.[47]

When selecting a seed mix, verify seeds are from a reputable vendor that can certify that the mix is free of noxious, invasive weeds or species intolerant to drought. Options for native plant species will vary depending on the height and spacing of the panels as well as which area of the site is being planted (panel zone area vs buffer zone area). Raised panel designs accommodate a wider variety of species and allow for easier and less frequent mowing, but material costs will also increase. When possible, it is recommended to increase the height of the bottom edge of the panels up to 36 inches from the ground surface to increase benefits while keeping installation costs lower.[48] Depending on panel height design, plants planned for the panel zone should have a maximum height of 2 feet while those for buffer zones could have a maximum height of 3-4 feet. The implementation of these practices site-wide at large, utility-scale facilities may be challenging, but incorporating native plantings in a section or in several sections of a facility will also benefit ecosystems and wildlife.[49,50] For situations where rapid stabilization is essential or when use of native plants is not feasible, selection of non-invasive wildlife-friendly plants like clover should be prioritized where possible. For more information, review the resources provided in the Additional Resources section of this document (Native plant and pollinator resources).

[44] National Renewable Energy Lab (2023). Vegetation Management Cost and Maintenance Implications of Different Ground Covers at Utility Scale Solar Sites. https://www.mdpi.com/2071-1050/15/7/5895
[45] Blaydes, H., Potts, S.G., Whyatt, J.D., and Armstrong, A. (2021) Opportunities to enhance pollinator biodiversity in solar parks. *Renewable and Sustainable Energy Reviews* 145 https://doi.org/10.1016/j.rser.2021.111065.
[46] Macknick, J., Beatty, B., & Hill, G. (2013). Overview of Opportunities for Co-Location of Solar Energy Technologies and Vegetation. Retrieved from https://www.nrel.gov/docs/fy14osti/60240.pdf
[47] National Renewable Energy Lab (2023). Vegetation Management Cost and Maintenance Implications of Different Ground Covers at Utility Scale Solar Sites. https://www.mdpi.com/2071-1050/15/7/5895
[48] South Carolina Solar Habitat Act (2021). Technical guidance for the development of wildlife and pollinator habitat at solar farms. https://www.clemson.edu/public/regulatory/fert-seed/solar/tech-guidance.pdf
[49] Walston, L., and Ennen, J. (2023). An Array of Challenges – and Opportunities. Wildlife Professional 17(3): 32-37. https://wildlife.org/wp-content/uploads/2023/05/TWP_17.3_TOC.pdf
[50] Pedrini, S. et al (2020). Collection and production of native seeds for ecological restoration. *Restoration Ecology* 28(S3): S228-S238. https://doi.org/10.1111/rec.13190

Increase Engagement with Local Communities

Solar developments can provide a myriad of local benefits for communities and landowners, but these must be balanced with concerns about the loss of agricultural lands, impacts to habitat, wildlife and biodiversity, and the aesthetic impact of large utility-scale solar facilities. Due to the size of PV solar facilities, considerable care is required to plan for these facilities at the local level. The process and applicability at the local level varies throughout Georgia based on each planning department's priorities and resources. PV solar facility projects frequently require a special exception or conditional use approval, which involves a detailed local review, including the inclusion of certain conditions into the project plan before local approval may be granted. Early coordination can support the ability of local governments to evaluate solar projects more quickly and thoroughly and to identify those development conditions that may be necessary to secure project approval by a local government.

It is important to consider and address any local planning and zoning restrictions or regulations as the site design is developed. Even if not required by local planning and zoning regulations, project applicants should consider providing the following plans during application submittal to help local officials, neighbors, and the public understand how project developers will protect on- and off-site natural resources and avoid, minimize, and mitigate potential impacts:

- **Site plan**: Include the placement of the solar facility on the project site, consistent with local zoning and land development regulations. Identify relative location of transmission lines. Also include roadways and facility access roads; fence, property, and tree lines; vegetation; wetlands, water features and associated buffers; contours; built structures including stormwater facilities, buildings and parking pads; and other features as appropriate.
- **Grading plan**: The grading plan should show existing and proposed contours across the extent of the site; limit grading to the greatest extent possible by avoiding steep slopes; take account of and preserve natural drainage patterns; phase grading across the extent of the project area to reduce exposed soil; and incorporate relevant practices to minimize erosion and stormwater runoff to the greatest extent practicable (See below).
- **Erosion, Sedimentation and Pollution control plan**: Erosion and sedimentation from all sources is the number one source of pollution to Georgia's waters. Solar developers should fully comply with State and County erosion and sedimentation control guidance to avoid or minimize impact to on- and off-site resources, including waters of the state.[51] Any type of construction project which is one (1) acre or more must have an Erosion, Sedimentation and Pollution Control (ES&PC) plan prepared in accordance with the state NPDES Permit, but additional local requirements may vary. Incorporating a range of BMPs from the *Manual for Erosion and Sediment Control in Georgia ("Green Book")*[52] in conjunction with each other is recommended for avoiding, minimizing, and mitigating erosion and sedimentation, decreasing project delays, reducing unexpected costs, and avoiding violations. Examples include appropriately sized sediment basins, high quality silt fencing, compost filter socks, straw bales, mulching, riprap, check dams, diversion beams, phasing of land disturbance and stabilization of disturbed areas. Mortality to snakes, birds, small mammals, and other wildlife occur when they become entangled in erosion control mesh, so incorporate the use of biodegradable materials and larger mesh sizes when practical. The use of biodegradable mesh is most important in areas where sensitive species occur, and within or near upland habitats,

[51] Rules and Regulations of the State of Georgia Subject 391-3-7 Erosion and Sedimentation Control: https://rules.sos.ga.gov/gac/391-3-7.

[52] Manual for Erosion and Sediment Control in Georgia (Green Book) (2016). *https://gaswcc.georgia.gov/urban-erosion-sediment-control/technical-guidance*

wetlands, rivers, and lakes. USFWS has also developed additional resources to support the use of wildlife-friendly erosion control.[53]

- **Stormwater plan**: A well-developed stormwater management plan is essential for protecting waters of the state. Determining pre- and post- construction stormwater coefficients is **required** by the NPDES Permit for the proper design and installation of pre- and post- construction stormwater BMPs. Stormwater management guidance for the state of Georgia can be found at the GA EPD Stormwater Management website.[54] Proper implementation of selected stormwater practices as described in the Georgia Stormwater Management Manual ("*Blue Book*")[55] or in resources provided by the U.S. Environmental Protection Agency (EPA)[56] will help project developers avoid costly delays for mitigation or remediation of impacts to water resources.
- **Vegetation management plan**: Local ordinances may or may not require a vegetation management plan with the project application; however, designers should consider developing such a plan even when not required. These plans, which often including a rendering of the site with proposed vegetation, allow planning and zoning staff and the public the opportunity to understand how the project will affect views from public roads and neighboring properties. A well-designed vegetative buffer that screens the facility from public view can soften the aesthetic impact of large-scale solar facilities. Vegetative buffers can also mitigate localized changes in heat or wind patterns that can occur when sites are cleared.

Enhance Agricultural Opportunities

Agricultural use of solar developments is increasing in popularity and feasibility, and consideration of this early during the site design phase will maximize the effectiveness of this opportunity given implications for project engineering and design. The practice of using sheep on solar facilities for conservation grazing is increasing in Georgia. Effective utilization of sheep grazing can create an additional revenue source while also managing vegetation on-site and contributing to soil health, and solar facilities provide these sheep with shelter and food resources.[57] If sheep grazing is being considered, there are some site design aspects to consider during planning. Selection and planting of appropriate seed mixes should be incorporated into the site planning to protect the health of the sheep. Additionally, wildlife-friendly fencing may increase the chances of livestock escape or predation, so more traditional fencing may be preferred in facilities that wish to incorporate sheep grazing into their management plan.

Some areas in the US are experimenting with more traditional row crop or specialty crop production designs, but the increased panel height required to accommodate tractors is often cost-prohibitive at larger scales due to higher installation and material costs. The National Renewable Energy Laboratory notes that while a torque tube height of 6 feet is the minimum height for crop production under panels, farmers prefer torque tube heights of 8 feet or higher. Greater heights allow for more uniform shading of crops and easier, safer access for farmers and small equipment. Lower torque tubes and panel heights

[53] https://www.fws.gov/initiative/protecting-wildlife/make-change-wildlife-friendly-erosion-control-products
[54] Georgia Environmental Protection Division. Watershed Protection: Stormwater. https://epd.georgia.gov/watershed-protection-branch/stormwater
[55] Georgia Stormwater Management Manual Volumes 1 and 2. 2016 Edition. https://atlantaregional.org/natural-resources/water/georgia-stormwater-management-manual/
[56] https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater
[57] Walston LJ et al (2022). Opportunities for agrivoltaic systems to achieve synergistic food-energy-environmental needs and address sustainability goals. *Front. Sustain. Food Syst.* 6:932018. https://www.frontiersin.org/articles/10.3389/fsufs.2022.932018/full

limit crop production to rows between, rather than under, solar panels.[58] For agricultural uses like grazing or crop production, nutrient management planning will need to be considered. If panels will be raised for co-location of agriculture, additional variations within native plantings can also be incorporated into the final vegetation plan. If the proposed facility is in proximity to other fields with crop production, incorporating pollinator habitat on site can also improve pollination of adjacent fields crops.

Summary of Site Design Considerations
• **Reduce barriers to wildlife movement through thoughtful consideration of retention of unfenced passageways or wildlife-friendly fencing practices.**
• **Minimize watershed impacts through avoidance of wetlands and increased vegetative buffers around wetlands and streams where possible. Consider practices such as incremental increases in panel spacing, especially in areas with erosional soils, significant land clearing, or highly sloped sites.**
• **Provide on-site habitat through avoidance of unnecessary vegetation clearing, purposeful retention of habitat diversity, and incorporation of native vegetation wherever practicable on all or on a portion of a site.**
• **Increase engagement with local communities to understand local priorities and challenges and how those priorities could be incorporated into your site design choices. Consider providing more detailed plans that demonstrate these efforts during the application process, even if not strictly required by local planning and zoning regulations.**
• **Where appropriate, consider site design elements that can allow integration of solar with agricultural operations, such as grazing livestock or growing specialty crops that perform well under solar panels.**

Site preparation and construction

After a thoughtful site design has been developed and all federal, state, and local permits and approvals have been acquired, implementation of the approved plans for construction and for stormwater management during site development is essential to ensure impacts are avoided or minimized and proposed benefits are delivered. To facilitate implementation, it is important to develop a process to communicate these plans and expectations to the contractor and/or sub-contractors responsible for site preparation, vegetation management, and construction. Also, ensure there is a plan in place to communicate with the local issuing authority to plan the erosion and sedimentation inspections required before, during, and after construction as specified in your permit.

Prior to beginning any land disturbing activity, initial sediment storage requirements and all perimeter controls (silt fencing, sediment ponds, etc.) should be installed and maintained in accordance with the

[58] Macknick, Jordan et al (2022). The 5 Cs of Agrivoltaic Success Factors in the United States: Lessons From the InSPIRE Research Study. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-83566. https://www.nrel.gov/docs/fy22osti/83566.pdf.

NPDES Permit and your ES&PC Plan until final stabilization is achieved and a Notice of Termination is completed. Stabilization may be achieved faster if vegetation can be established prior to construction. Approved perimeter controls should encompass the entire site, and if the project is phased, perimeter controls should be implemented in the disturbed phased segment also. If non-biodegradable materials have been selected for erosion control, recognize and mitigate for the risk of wildlife entanglement wherever possible. If vegetation plans include the use of native pollinator species planted after construction, recognize that they may be slower to establish. Coordinate with your local issuing authority to determine best practices for the temporary stabilization of your unique site to ensure permit compliance throughout.

Certain construction and site preparation practices (e.g., removal of topsoil and vegetation) as well as maintenance activities (e.g., vehicle operation between panels) can have long-term impacts to soil health at PV facilities. If these activities significantly impact the onsite soil, it may influence the speed and quality of revegetation efforts. Various mitigation activities (e.g., soil ripping or aeration, low-pressure tires or even tracked vehicles) could be considered to support soil health.[59] On steeper slopes, it is more crucial to protect existing topsoil and evaluate where flow may concentrate (drip lines) off the panels toward the nearest low-lying area. On these sites, it is important to slow the rate of flow by creating areas perpendicular to the flow paths to slow the rate of flow, which increases infiltration of water into the soil. On all sites, it is recommended that solar developers create construction plans that avoid unnecessary vegetation clearing and maintain topsoil with native vegetation to the greatest extent possible. While tree clearing intended for site preparation is generally treated as development rather than silviculture/forestry, the established practices for forestry management may still provide helpful guidance. Any tree clearing activities should stay out of all mandated stream buffers (or streamside management zones). If stream buffers are impacted, no other land-disturbing activities, except for normal forest management practices, will be allowed on the entire property for a period of three years after the completion of such forestry practices per O.C.G.A 12-7-17 (6).[60]

A careful selection of seed mixes that align with the local eco-type can provide habitat for pollinators as well as improve overall diversity of habitat for wildlife. To prepare for planting, there may be a need to remove existing invasive, agricultural weeds, or non-desired vegetation, and selective herbicide application may be required for successful elimination. It is important to consider past land use, specifically any previous pre-emergent herbicide or persistent pesticide use on site, when determining the approach for weed control and seed mix selection. Certain pesticide residues can remain in the soil for extended periods of time and inhibit native seed germination. While sometimes necessary to achieve the vegetation management goals for the site, any unnecessary use of herbicide is often considered controversial as it may have negative ecological impacts. When herbicide use is necessary, only apply according to label specifications. For additional information, review resources such as the South Carolina Department of Natural Resources technical guidance on the Development of Wildlife and Pollinator Habitat at Solar Farms.[61]

[59] Chamen, W.C.T., et al (2015). Mitigating arable soil compaction: A review and analysis of available cost and benefit data. *Soil and Tillage Research* 146(A): 10-25. https://doi.org/10.1016/j.still.2014.09.011.
[60] O.C.G.A 12-7-17 (6): https://gaswcc.georgia.gov/sites/gaswcc.georgia.gov/files/related_files/document/OCGA_June_2016.pdf
[61] https://www.dnr.sc.gov/solar/assets/pdf/solarHabitatGuide.pdf

Summary of Site Preparation and Construction Considerations
• **Implement approved plans for construction and stormwater management at all phases of site development. Communicate plans with contractors or sub-contractors that will be responsible for site preparation and construction.**
• **Prior to beginning any land disturbing activity, approved erosion control measures (silt fencing etc.) should be placed between the disturbed area and any nearby waterways and maintained in a functioning capacity until the area is permanently stabilized. Prioritize topsoil protection and management on sites with steeper slopes.**
• **Avoid unnecessary removal of topsoil or vegetation to minimize long-term impacts to soil health and hydraulic conductivity. Tree clearing in preparation of solar development should be handled as a development project rather than as silviculture. Unnecessary removal of trees should be minimized, and any tree clearing activities should stay out of all mandated stream buffers (or streamside management zones).**
• **Incorporate conservation practices into vegetation management. Use native and local ecotype seed mix sources when practicable to restore and/or augment the herbaceous vegetation.**
• **To prepare for site planting, existing invasive, agricultural weeds and non-desired vegetation should be eliminated prior to planting, taking into consideration past use of pre-emergent herbicides or persistent pesticides. Depending on the composition of existing vegetation, selective herbicide application following all label specifications prior to planting may be necessary.**

Maintenance and end-of-life

Vegetation Management

During the life cycle of a facility, maintenance practices can either enhance or detract from wildlife-focused efforts developed during the site design and construction phases. Vegetation management after a site is established is an ongoing opportunity to reduce impacts to wildlife. Depending on the vegetation used on site, maintenance needs will vary. When native species are being used, early maintenance may be more involved, but this effort may be rewarded by reduced maintenance once established.[62] The first year of maintenance may require repeated mowing to address and minimize weedy growth. If possible, avoid mowing vegetation to a height lower than 6 inches, as mowing lower than this height may stunt the growth of pollinator plants. Once established, maintenance in following years will be reduced. Once native vegetation is established, minimal annual herbicide may be necessary only for spot-spraying of woody vegetation and invasive species. Some form of disturbance (like mowing or grazing) will be needed periodically to prevent establishment of woody vegetation and reduce risks posed by standing dead vegetation adjacent to panels. When possible, mowing in early March or in a mosaic pattern throughout the winter can minimize adverse impacts to wildlife by enhancing native floral habitats while still providing cover to overwintering pollinators. If late fall mowing is necessary, leaving several inches of remaining vegetation can help maintain some winter habitat. Posted informational signage is encouraged to explain the process, as native plantings can take several years to become established and have aesthetic value.

[62] North Carolina Technical Guidance for Native Plantings on Solar Sites. V2 May 2022: http://ncpollinatoralliance.org/wp-content/uploads/2022/06/NC-Solar-Technical-Guidance-FINAL-May-2022.pdf

Environmental Contamination

Most studies generally report low contamination risk for most metals associated with PV panels. The global photovoltaic (PV) solar market is dominated by two solar module classes – crystalline silicon (c-Si) and cadmium telluride (CdTe). c-Si panels dominate the solar market, accounting for 84% of deployed PV panels in the United States and 96% of global PV module shipments in 2020.[63] Depending on the class (i.e., c-Si or CdTe), PV panels can contain several hazardous elements, such as cadmium, gallium, telluride, selenium, and lead. However, c-Si and CdTe panels comprise mainly glass and other non-hazardous materials (aluminum, silicon, and polymers), with less than 1% of all materials by weight being hazardous elements, such as lead, tellurium, and cadmium.[64] Two reports produced by The International Energy Agency indicate that breakage rates of PV modules (e.g., cracks in the glass or frame) are rare events (0.04%) during operations of the PV solar facility, and human health risks from lead in c-Si panels and cadmium in CdTe panels were orders of magnitude lower than screening values of lead in the environment (i.e., soil, air, and water) and below screening thresholds for cancer and non-cancer hazards for cadmium established by EPA.[65,66] Robinson and Meindl assessed the potential for leaching contaminates from c-Si panels in the soil of an operational facility and found that no elements were in high enough soil concentrations to pose risks to wildlife and the ecosystem.[67]

Site Decommissioning and Reclamation

The technology involved in larger scale solar development is continually evolving, so recommended practices for facility end-of-life planning and site decommissioning are continuing to adapt as well. Landowners may see increased agricultural yields from soils restored by decades of proper habitat management during solar leases[68]. However, the land must be properly decommissioned following lease termination in order to be suitable for agricultural purposes. As of April 22, 2024, Georgia statute (46-3-67 through 69.1) now establishes required provisions for solar power facility agreements executed or renewed after July 1, 2024 regarding responsibilities for decommissioning solar power equipment, including the requirement for the developer to provide financial assurances for required decommissioning activities. A solar site reclamation plan should include provisions for what needs to be removed (posts, underground cables, concrete pads, etc.), who is responsible for reclamation or cleanup after the lease is terminated, how the site will be restored, and details of financial assurances for cleanup.

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[63] U.S. Department of Energy (February 2022). Solar Photovoltaics: Supply Chain Deep Dive Assessment: https://www.energy.gov/sites/default/files/2022-02/Solar Energy Supply Chain Report - Final.pdf

[64] Mirletz et al. (2023). Unfounded concerns about photovoltaic module toxicity and waste are slowing decarbonization. Natural Physics 19:1376-1378. https://www.nature.com/articles/s41567-023-02230-0

[65] Sinha, P. et al (2018). Human health risk assessment methods for PV, Part 1: Fire risks, International Energy Agency (IEA) PVPS Task 12, Report T12-xx:2018. https://iea-pvps.org/key-topics/hhra-methods-for-pv-part1-by-task-12/

[66] Sinha, P. et al (2019). Human health risk assessment methods for PV, Part 3: Module disposal risks, International Energy Agency (IEA) PVPS Task 12, Report T12-16:2020. https://iea-pvps.org/key-topics/human-health-risk-assessment-methods-for-pv-part-3-module-disposal-risks/

[67] Robinson and Meindl (2019). Potential for leaching of heavy metals and metalloids from crystalline silicon photovoltaic systems. Journal of Natural Resources and Development 09:19-24: https://journals.ub.uni-koeln.de/index.php/JNRD/article/view/774/795

[68] South Carolina Solar Habitat Act (March 2021). Technical guidance for the development of wildlife and pollinator habitats at solar farms: https://www.dnr.sc.gov/solar/assets/pdf/solarHabitatGuide.pdf

While information about panel breakage rates during end-of-life activities is not currently available,[69] the overall contamination risk from PV panels to wildlife and humans is low and will be further reduced as manufacturers adopt lead-free solder and viable recycling programs for end-of-life PV panels, which would further eliminate any minor contamination risks associated with landfill disposal.[70] For more information about site decommissioning, review the Decommissioning Solar Energy Systems Resource Guide[71] or the Fact Sheet produced by the Compliance Monitoring and Enforcement Task Force for Hazardous waste.[72] For additional information about panel recycling, please review resources available through the Solar Energy Industries Association.[73]

Summary of Maintenance and End of Life Considerations
• **Ensure construction and operation plans that incorporate conservation practices are communicated with the contractors involved in site maintenance. Post informational signage to clarify the process of establishing native or pollinator-friendly habitats.**
• **Consider the long-term benefits of establishing native vegetation. Practice conservation mowing such as not mowing vegetation lower than 6 inches, especially when using native or pollinator-friendly vegetation. Mow in a mosaic pattern in March (ideal) or sporadically during winter if necessary. Employ selective spraying for unwanted woody vegetation on a limited basis when necessary to avoid impacts to desired species.**
• **Georgia law requires developers to provide a decommissioning plan as well as financial assurances for decommissioning activities. The plan should specify what needs to be removed, who is responsible for these actions, and to what condition the site will be restored.**
• **Recycle solar panels and other solar equipment at the end of its useful lifespan whenever possible and encourage adoption of viable recycling programs.**

[69] Zeng et al. (2015). Cadmium telluride and cadmium selenide leaching behavior and surface chemistry in response to pH and O2. Journal of Environmental Management 154:78-85. https://www.sciencedirect.com/science/article/abs/pii/S0301479715001085?via%3Dihub

[70] Mirletz et al. (2023). Unfounded concerns about photovoltaic module toxicity and waste are slowing decarbonization. Natural Physics 19:1376-1378. https://www.nature.com/articles/s41567-023-02230-0

[71] Kolbeck-Urlacher, H. (2022). Center for Rural Affairs. Decommissioning solar energy systems. https://www.cfra.org/publications/decommissioning-solar-energy-systems

[72] ASTSWMO CME and SMM Task Forces (2022). Fact Sheet: Photovoltaic Modules. https://astswmo.org/files/Resources/Hazardous_Waste/2022-11-PV-Modules-Fact-Sheet.pdf

[73] SEIA National PV Recycling Program. Accessed June 2023. https://www.seia.org/initiatives/seia-national-pv-recycling-program

Focal species of concern

Georgia's extensive biodiversity can make it challenging to prioritize conservation efforts on those species most likely to interact with solar development. This section provides an overview of the species of conservation concern that are frequently considered during solar project development in Georgia, either due to habitat overlap or other life history characteristics that result in increased sensitivity to solar installation construction and maintenance practices. For each focal species, this section includes a species profile as well as conservation recommendations that may help during project planning. Please note that this does not include an exhaustive list of all possible species to consider and should not be used in place of site-specific review.

Reptile Species of Concern

Gopher Tortoise (Gopherus polyphemus; State Listed: Threatened[74])

Gopher tortoises are a characteristic species of the longleaf pine and wiregrass community, which includes sandhills, dry flatwoods, and turkey oak scrub in the Southeastern Plains and Southern Coastal Plain Ecoregions. Gopher tortoises occupy upland sandy soils and prefer open areas with a diverse mix of herbaceous vegetation for forage. However, gopher tortoises can be found in areas that have become degraded by habitat fragmentation, fire suppression, and agricultural practices. They are known to eat over 400 different species of plants. Broadleaf plants and grasses are important, but it is estimated that 70-80% of their diet is composed of grasses. Threats to gopher tortoise populations include loss and alteration/isolation of their historic longleaf pine-wiregrass communities caused by urban sprawl, fire suppression, and agricultural or silvicultural activities. Land characteristics of large private lands results in frequent overlap between solar projects and gopher tortoises in Georgia and other southeastern states.

They serve as ecosystem engineers through excavation of burrows that can extend underground for thirty feet and serve as important refugia for more than 360 other species, including many Species of Greatest Conservation Need. Gopher tortoise burrows are domed or half-moon-shaped and at the mouth of the burrow is a mound of soil known as the "apron". The apron is where the female will typically lay and bury her eggs between May and June. Incubation lasts 80 to 100 days. Hatchling tortoises also dig their own burrows and can be difficult to detect, often nestled beneath bunch grasses or other herbaceous plants. Active burrows may not appear active during winter months due to reduced gopher tortoise activity. In Georgia, impacts to gopher tortoise burrows are prohibited and burrows should not be collapsed during land disturbing activities. Contact the GA DNR Wildlife Resources Division Wildlife Conservation Section[75] as soon as gopher tortoise burrows are found on site. Every burrow must be marked and located prior to any land management activities, so it is recommended that this be done before beginning the permit application process. If gopher tortoise burrows are present on site, a Scientific Collection Permit to survey, capture, or translocate impacted tortoises from the GA DNR Law Enforcement Division Special Permits Unit, in cooperation with the Georgia Wildlife Resources Division Wildlife Conservation Section, will be required before any work can begin. After consultation and a plan for avoidance and minimization has been made, permit issuance lead time is 4-6 weeks. In the case of gopher tortoise translocations, permit applications should include a detailed relocation plan. When considering gopher tortoise translocation, timing of activities should be thoroughly considered. Gopher

[74] Gopher tortoise: https://georgiabiodiversity.org/portal/profile?group=reptiles&es_id=20476 or https://ecos.fws.gov/ecp/species/6994.

[75] https://georgiawildlife.com/about/what-we-do#nongame-conservation. Contact Wildlife Biologist James.Hunt1@dnr.ga.gov for additional information.

tortoise translocation activities (capture, transport, and release) should occur during late March – May or September – October, when daily high temperatures do not exceed 90 degrees F and daily lows are above 50 degrees F for at least three days after release.

If permitted, tortoises may be moved to suitable habitat on site but outside of the construction area if they are penned with quality silt fencing for 9-12 months. Unimpacted gopher tortoises outside of the construction area should be fenced out using quality silt fencing. Gopher tortoise habitat on site can be improved within the arrays and outside the arrays by planting a diverse mixture of native, low-growing grasses and forbs for forage, reducing mowing, raising mower deck heights, or utilizing a wildlife-friendly fencing design with an 8-12 inch gap at the bottom to allow movement in and out of the solar site. If fence gaps are being considered, consult with GA DNR to develop a project proposal for your Scientific Collection Permit application that includes plans for monitoring, research, management, and contingencies. In other cases, gopher tortoises may be translocated off-site onto suitable habitat with appropriate land management practices in place and an easement that prohibits development in the future. Certain translocations may also require monitoring the potential for disease transfer. In these cases, land management plans, land protection status, and monitoring must be carefully considered.

Eastern Indigo Snake (Drymarchon couperi; Federally Listed: Threatened[76])

The Eastern indigo snake in Georgia is closely associated with the gopher tortoise (*Gopherus polyphemus*) due to the tortoise's excavation of extensive underground burrows that indigo snakes depend on for shelter from winter cold and summer desiccation. Indigo snakes often utilize gopher tortoise habitats for breeding in the winter months and are known to lay eggs in the apron of gopher tortoise burrows in the spring. Their preferred habitat is typically an open-canopied forest that allowed abundant sunlight penetration and conditions favorable for a rich growth of herbaceous vegetation. Today, little of this habitat still exists and many gopher tortoise populations are now found in degraded habitats such as roadsides and old fields that retain the three key habitat requirements: sandy soil for burrow excavation by gopher tortoises, sunlight, and abundant herbaceous vegetation. Thus, indigo snakes may also be present in degraded gopher tortoise habitat. During the warmer months, indigo snakes can also be found foraging during the day on the edge of wetlands where frogs and other snakes typically are abundant. In Georgia, adult indigo snakes have large home ranges and may move as much as 5 miles or more from the overwintering sandhill habitat, often returning to the same sandhills and sometimes the same burrows in winter. Threats to the Eastern indigo snake include loss and fragmentation of sandhill habitats that support gopher tortoises, removal of prescribed fire, which maintains suitable understory habitat, and declining gopher tortoise populations. Because of the limited distribution of this species and its federal status, suitable indigo snake habitat should be avoided whenever possible. USFWS should be contacted for any potential project sites that are within the range of the Eastern indigo snake and contain suitable gopher tortoise habitat.

Florida Pine Snake (Pituophis melanoleucus mugitus; under federal review[77])

The Florida pine snake inhabits areas that feature well-drained sandy soils with a moderate to open canopy including sandhills, scrub, pine savanna, and old fields in the Southeastern Plains and Coastal Plain ecoregions of Georgia. The primary threat to the Florida pine snake is habitat loss through development or alteration of the fire regime leading to the encroachment of hardwood tree species. Food availability is also a threat since the pocket gopher, a preferred food, is also experiencing declines throughout these habitats.

[76] https://www.fws.gov/story/eastern-indigo-snake-conservation
[77] https://myfwc.com/wildlifehabitats/profiles/reptiles/snakes/florida-pine-snake/

Southern Hognose Snake (Heterodon simus; State Listed: Threatened[78])
The Southern hognose snake is most often associated with well drained, xeric, sandy soils where longleaf pine and/or scrub oaks (especially turkey oak) are the characteristic woody vegetation. Wiregrass is often a significant component of the groundcover. Such habitats are necessarily fire-maintained. Ruderal habitats, including fallow fields, may also be used. Southern hognose snakes are primarily found in the Coastal Plain from southeastern North Carolina south and westward to the Pearl River in southern Mississippi, including much of peninsular Florida. This species is widely distributed in the Coastal Plain of Georgia but tends to occur in small, disjunct populations that are sometimes isolated by several miles from the closest neighboring one. The destruction and alteration of longleaf pine-wiregrass and other xeric habitats has been implicated in the decline of many associated species; however, southern hognose snakes have apparently disappeared from some of the best remaining examples of these habitats. Further, the species persists in areas of other states where the native habitat has been highly altered. Non-native invasive predators (especially red imported fire ants), road mortality, and human persecution may also contribute to species declines.

Gopher Frog (Lithobates capito; under federal review[79])
The gopher frog is a stout, medium-sized frog found in longleaf pine ecosystems in the southeastern U.S coastal plain. It occurs in sandy and well drained, longleaf pine/saw palmetto/wiregrass sandhills as well as more poorly drained longleaf pine flatwoods. The longleaf pine uplands and open-canopied, grassy wetlands favored by this species are fire-maintained communities, so gopher frogs utilize animal burrows for shelter (including those of gopher tortoises, oldfield mice, or crayfish in wetter flatwood areas). During breeding, gopher frogs migrate to breeding ponds in the fall, winter, and early spring during heavy rains where they utilize isolated, depressional wetlands like cypress ponds, limesink ponds, and Carolina bays. The wetlands used by breeding gopher frogs are typically ephemeral and always lack larger, predatory fish species. Optimal sites for this species are sandhill or flatwoods landscapes large enough to contain a group or cluster of isolated wetlands. Maintaining habitat connectivity between uplands and wetlands is critical for this species.

Pronounced habitat fragmentation means that small, isolated gopher frog populations are threatened by continued loss of fire-maintained longleaf pine communities as well as extreme weather events such as protracted drought. In areas with suitable gopher frog habitat, surveys are best conducted during the breeding season, which usually lasts from October through March, with peaks in October-November and February-March. Funnel traps placed at the mouths of gopher tortoise burrow have captured frogs at some sites, and drift fences equipped with funnel or pitfall traps and placed adjacent to potential breeding ponds can intercept migrating adults but are cost and labor intensive.

Conservation Measures for Herpetofauna of Concern (i.e., reptiles and amphibians)
1. Ensure species-specific surveys for the Eastern indigo snake[80] and gopher tortoise are completed per agency guidance when appropriate.
2. Ensure appropriate agency consultation is completed if project may affect listed species. Adherence to agency guidance is recommended to avoid a determination that the project is "likely to adversely affect" listed species, which may require additional review/ permitting with

[78] https://georgiabiodiversity.org/portal/profile?group=reptiles&es_id=20606
[79] https://georgiabiodiversity.org/portal/profile?group=amphibians&es_id=21226
[80] https://www.fws.gov/media/visual-encounter-survey-protocol-eastern-indigo-snake-drymarchon-couperi-georgia

	USFWS in order to receive authorized take and avoid violation of Section 9 of the Endangered Species Act.[81]
3.	**Implement the Standard Protection Measures[82] for the Eastern indigo snake during all phases of construction activities. While these measures state that handling or harassment of an Eastern indigo snake is not allowed, moving a snake out of harm's way during project construction activities may be authorized under certain circumstances outlined in an Incidental Take Statement or Permit. If an Eastern indigo snake is discovered, the snake should not be handled (without an Incidental Take Statement or Permit already in place) and the USFWS should be contacted immediately.**
4.	**Coordinate early with GA DNR if gopher tortoise burrows are present on site. Before any site disturbance can begin, burrows should be marked, and a Scientific Collection Permit must be obtained to scope burrows or to capture or translocate impacted tortoises. If burrow excavation will be required, ensure coordination with GA DNR includes a plan to address additional commensal species of concern that may be discovered utilizing a burrow.**
5.	**Implement a policy that prohibits killing or harming snakes during construction or site maintenance activities. Ensure that workers familiarize themselves with the defining characteristics of the snake species that may be present. If any are encountered, photograph for identification and record date and detailed location information.**
6.	**Construction areas should be clearly marked or staked to designate the limits of clearing and earth works. If there are staging areas, then those areas should be clearly marked to establish a controlled area for construction material and equipment. For sediment and erosion control during construction, use wildlife friendly silt control products that do not contain plastic netting or similar material that could entangle reptiles.**
7.	**A qualified biologist should be present during gopher tortoise excavation activities. All gopher tortoise burrows, active or inactive, should be evacuated via methods pursuant to Florida Fish and Wildlife Conservation Commission (FWC) excavation guidance[83] prior to collapsing any burrow. Commensal species encountered during excavation should follow the plan developed during coordination with GA DNR. Generally, it is suggested that commensal species be released on-site across a physical barrier separating them from development activities or allowed to escape unharmed.**
8.	**Holes, cavities, and snake refugia (including artificial materials such as construction materials or abandoned pipes) other than gopher tortoise burrows should be inspected each morning before resources are manipulated, dismantled, or moved.**

Mammal Species of Concern

Southeastern Pocket Gopher (Geomys pinetis; State Listed: Threatened[84])

Southeastern pocket gophers are the only state threatened, non-bat mammal that occurs in the Coastal Plain and Sandhills. This species is highly adapted for digging and life underground and has extremely limited dispersal, often spending their entire lives within their own burrow system. They prefer fields, pastures, and savannas, or other habitats with diverse understory and well-draining soils with low clay content. Habitat loss and fragmentation of longleaf pine savanna ecosystems appear to the be primary

[81] https://www.fws.gov/laws/endangered-species-act/section-9
[82] https://www.fws.gov/story/eastern-indigo-snake-conservation
[83] https://myfwc.com/license/wildlife/gopher-tortoise-permits/permitting-guidelines/
[84] https://georgiabiodiversity.org/portal/profile?group=mammals&es_id=18839

factors causing the decline of this species. Additionally, the species has limited above-ground dispersal, with roads, rivers, and bottomlands serving as barriers. Overcoming above-ground barriers through translocation is not preferred due to high mortality during relocation.

American Black bear (Ursus americanus[85])
An isolated population of black bears resides in Central Georgia (CGA) within Bibb, Bleckley, Houston, Pulaski, Twiggs, and Wilkinson counties. Bears need large acreage of wooded habitat and previous projects showed that uplands were more important than the Ocmulgee River floodplain due to its frequent flooding. The current and potential future loss of more upland wooded habitats within the CGA footprint by all causes is concerning. Female black bears in the CGA may be more vulnerable to habitat loss than males due to smaller home range size. The CGA is already recognized as having genetic issues with inbreeding, along with a slower reproductive rate than other eastern populations. Therefore, anything that lowers the amount of available habitat for females will only cause more issues with this population. Large-scale solar facilities that require extensive forest clearing or significant sites that could be alternatively restored to provide high-quality forested habitat in these counties should be avoided.

Gray Bat (Myotis grisescens; Federally Listed: Endangered[86])
In Georgia, the gray bat range is restricted to the northern part of the state. Gray bats typically use cave habitats as roosts year-round but are occasionally known to use transportation structures at any time of year. Gray bats forage extensively on aquatic insects from perennial streams and large bodies of water. Development activities that are within a half-mile of a known roosting cave and are likely to impact caves through noise or disturbance could negatively affect gray bats. Activities negatively impacting aquatic ecosystems within the range of the gray bat could also harm this species by reducing prey availability. Unlike other listed bats in Georgia, gray bats do not roost on the forested landscape so tree clearing activities do not typically directly impact this species. However, tree removal in proximity to roost sites or along streams used for foraging may reduce the extent or quality of travel corridors available for use.

Indiana Bat (Myotis sodalis; Federally Listed: Endangered[87]) and Northern Long-eared Bat (Myotis septentrionalis; Federally Listed: Endangered[88])
The Indiana bat and the northern long-eared bat (NLEB) are restricted to northern Georgia. These bats use caves (or culverts and other transportation structures) in the winter to hibernate and are found utilizing the forested landscape (or culverts and other transportation structures) in the spring, summer, and fall. Indiana bats have only been observed in a very limited number of caves, culverts, and tree roosts in Georgia. Due to both species using tree roosts during the non-winter months, tree clearing is the most likely activity associated with large solar sites to negatively affect these species.

Careful consideration of tree clearing activities is even more critical because of the devastating effects of white-nose syndrome (WNS). WNS is a novel fungal disease that thrives in cold and humid conditions of caves and has resulted in a precipitous decline in bat populations across the country due to its high mortality rate and high transmissibility. It was first observed in Georgia caves in 2013 and has rapidly spread to other caves and culverts in Northern Georgia. Both Indiana and Northern long-eared bat populations are experiencing declines due to WNS, and the Northern long-eared bat is one of the three

[85] https://georgiawildlife.com/sites/default/files/wrd/pdf/fact-sheets/Bear%20Fact%20Sheet%200821.pdf
[86] https://www.fws.gov/species/gray-bat-myotis-grisescens
[87] https://www.fws.gov/species/indiana-bat-myotis-sodalis
[88] https://www.fws.gov/species/northern-long-eared-bat-nyctophilus-arnhemensis

species that has been most impacted in Georgia. NLEB were once very common in the forested landscape in northern Georgia but have been scarcely observed in recent years due to these significant population declines.

Tricolored Bat (Perimyotis subflavus; Federally Proposed: Endangered[89])
The tricolored bat can occur statewide in Georgia. This species uses the forested landscapes during the "active" seasons of spring, summer, and fall. They roost in leaf foliage, and nearly all forested areas could be considered suitable habitat, so tree removal or impacts to existing forested lands during site development are most likely to negatively affect this species. They can also be found in transportation structures, abandoned buildings, and military bunkers. In the winter, tricolored bats hibernate in caves and mines where these habitats are available. They have also been documented using culverts extensively for hibernation across most of Georgia. They also overwinter in bridges, but likely to a lesser extent than culverts. In bottomland hardwood forests, they have been documented in tree hollows. In much of Georgia, winters are mild enough that tricolored bats are likely active on the landscape to some extent year-round. Like other bat species that utilize caves in North Georgia, the tricolored bat is also experiencing negative impacts in Georgia from WNS and is one of the top three bats experiencing WNS mortality in Georgia.

Little Brown Bat (Myotis lucifugus; Under Federal Review for Listing[90])
The little brown has a widespread range in North America from Alaska-Canada boreal forests south through most of the contiguous United States and into central Mexico. Little brown bats primarily hibernate in caves and cave-like structures. They emerge from hibernation and disperse on the forested landscape for the spring, summer, and fall, so tree removal or impacts to existing forested lands during site development are most likely to negatively affect this species. often utilizing artificial structures for resting and maternity sites. Once abundant across its range, the species is experiencing significant declines in the eastern and southern portions of its range due to WNS. In Georgia, the little brown bat has only been documented in northern Georgia, where WNS is known to impact caves and cave-like structure. This significant decline has resulted in a federal review of the status of the little brown bat.

[89] https://www.fws.gov/species/tricolored-bat-perimyotis-subflavus
[90] https://www.fws.gov/species/little-brown-bat-myotis-lucifugus

Conservation Measures for Bats of Concern
1. Follow seasonal tree clearing restrictions for Indiana and northern long-eared bats if a proposed project is within the range of these species in North Georgia. Avoidance of tree clearing is preferable at any time when Indiana and northern long-eared bats are likely to be found roosting in trees (April 1-October 15), but at a minimum the non-volant pup season should be avoided (May 1-July 31). If not possible, please coordinate with the USFWS's Georgia Ecological Services Field Office (gaes_assistance@fws.gov) to determine if a presence or absence survey is appropriate.[91] Adherence to seasonal tree clearing restrictions (or surveys if not possible) is recommended to avoid a determination that the project is "likely to adversely affect" listed bat species, which may require additional review and permitting with USFWS in order to receive authorized take and avoid violation of Section 9 of the Endangered Species Act.
2. Tricolored bats are located statewide in Georgia. Tree clearing should be avoided during the non-volant pup season (May 1- July 31). Much of the state of Georgia is also within the year-round active area for this species. In those counties with potential year-round populations, tree clearing should also be avoided during the winter hibernation period (December 1- February 28). Please contact the USFWS's Georgia Ecological Services Field Office (gaes_assistance@fws.gov) if these timeframes for tree clearing are not feasible.
3. Avoid noise or disturbance activities within a half-mile of a known roosting cave of the gray, Indiana, northern long-eared, or tricolored bat.
4. Avoid activities negatively impacting aquatic ecosystems within the range of the gray bat as this could reduce prey availability and harm this species.
5. When surveys are warranted, follow the bat survey guidance provided by GA DNR.[92] Mist net and cave surveys (especially during winter months) should be done with care to avoid the spread of WNS. Do not disturb hibernating bats if encountered during cave exploration.
6. Reduce lighting to only that which is required for safe operation of the facility. Required lighting should be shielded or pointed downward to avoid attracting bats or birds.

Birds of Conservation Concern

Over the last 50 years, the total population of North American birds has declined by an estimated 3 billion birds. Many of the 1,093 species of birds protected under the MBTA (50 CFR 10.13) are experiencing population declines. Both natural and human-related sources of bird mortality contribute to declining bird populations. Mortality impacts are exacerbated by lost or degraded habitat, ecological alterations resulting from changing climate, and natural causes of mortality. Additional impacts to migratory birds are caused by common stressors which include vegetation alteration, vegetation removal, ground disturbance, structures, noise, light, chemicals, climate changes, and human presence.

The extent or primary causes of bird mortality from PV solar facilities in the southern U.S. are not well understood. Bird mortality resulting from interactions with electric utility lines have been a long-standing bird conservation issue with all forms of energy production and delivery, especially in the western U.S.[93] Interactions with electric distribution infrastructure can increase the risk of electrocution and fires, which can kill the birds and damage the equipment. Specific to solar, there has also been concern about a possible "Lake Effect" phenomenon which hypothesizes that glare from panels,

[91] https://www.fws.gov/media/range-wide-indiana-bat-and-northern-long-eared-bat-survey-guidelines
[92] https://georgiawildlife.com/BatSurveyGuidance
[93] Reducing Avian Collision with Power Lines: The State of the Art in 2012. http://www.aplic.org/uploads/files/15518/Reducing_Avian_Collisions_2012watermarkLR.pdf

polarized light, and night lighting may disorient birds or attract them to solar facilities. Research on this topic in the southwest highlights the challenges of attributing causes of avian mortality to PV solar interactions,[94] and newer panels coated with an anti-reflective material may minimize any possible "Lake Effect" risk. The most likely source of potential adverse impacts to avian species is collisions with project infrastructure; however, preliminary findings of a nationwide camera trap study have documented zero bird collisions so far.[95] Further studies focused on avian interactions in the southeastern U.S. are needed.

There are beneficial practices that can be incorporated into planning and implemented during construction, operation, and maintenance of a site to avoid and minimize impacts to birds of conservation concern. These solutions not only protect birds but also protect power supply reliability as electrocutions can cause power outages, damage equipment, and increase costs of operation and maintenance of the supply system. Utilities and other industries develop Avian Protection Plans using guidance[96] developed by the Avian Power Line Interaction Committee and USFWS to minimize risks to and from bird activities. Solar facilities can also provide habitat benefits for birds and other wildlife, especially when sites are designed and maintained with wildlife-friendly vegetation management in mind. Recent research is documenting more instances of bird species occupying and reproducing at PV facilities, but additional studies regarding the unique impacts of solar installations at a landscape level on bird behavior, reproduction, and diet are still needed.

Conservation Measures for Birds of Concern
1. Review nationwide guidance from USFWS on conservation measures for reducing impacts to birds and their habitat: https://www.fws.gov/media/nationwide-standard-conservation-measures.
2. Co-locate collector lines and generation tie lines with existing infrastructure or below PV panels whenever reasonable.
3. All new powerlines within high-risk avian areas should be constructed using avian-safe pole designs that follow an established Avian Protection Plan to minimize the risk of electrocution.
4. When significant vegetation clearing (i.e., tree removal, grading of vegetated areas, etc.) is necessary, try to limit clearing during the peak bird breeding season in that location.

Plant Species of Concern

There are more than 100 distinct environments or plant communities in the state. Among the geographic regions of the state, numerous ecosystems or environments exist where unique plants have adapted. In some cases, plant species have adapted to very specific and restricted environmental conditions. Others occur over much wider and more general environments. Depending upon past adaptive changes in each of these environments, some plants will be dominant while others will be rare or unable to survive. Plants grow where they do because they have finely adjusted to the local environment. Approximately 800 species of plants in Georgia are considered of special conservation concern, with 29 having federal protections and an additional 155 species protected by the state. Familiarize yourself with the site's specific environment and work with an experienced botanist to

[94] Kosciuch, K et al (2021). Aquatic Habitat Bird Occurrences at Photovoltaic Solar Energy Development in Southern California, USA. *Diversity* 13, no. 11: 524. https://doi.org/10.3390/d13110524

[95] Hamada, Yuki and Szymanski, Adam. October 2023. Developing a Machine-Vision Framework to Monitor Avian-Solar Interactions with PV Solar Facility Infrastructure. Argonne National Laboratory. https://anl.app.box.com/s/c9ot56h0nbuk9uy45l07f5e8wa52y7bh

[96] https://www.aplic.org/uploads/files/2634/APPguidelines_final-draft_Aprl2005.pdf

determine the potential presence and risk of impact to these species. Wherever possible, avoid unnecessary ground disturbance, vegetation removal, and/or introduction of non-native invasive plant species.

Hairy rattleweed (Baptisia arachnifera; Federally listed: Endangered[97])
This federally protected plant is one of the rarest plants in Georgia, found only in coastal flatwoods in a small portion of Wayne and Brantley counties. It shares some but not complete overlap with gopher tortoise soils, tending towards slightly wetter habitats. Because of the extremely limited distribution of this species and its federal status, hairy rattleweed populations should be avoided during site selection.

Conservation Measures for Plant Species of Concern
Avoid impacts to rare plant species whenever possible and maintain native plant communities on or near site whenever possible. If avoidance is not possible, coordinate with State and/or Federal agencies to develop a plan for plant relocation.

Pollinators and Pollinator Habitat

Pollinator habitat consists of flowering, herbaceous native plants and grasses that provide food and cover for pollinators such as bees, butterflies, moths, birds and more. Many of these species that use open prairies and grasslands are in decline in the Eastern United States due, in part, to habitat loss. The planting of native plant species not only improves early successional habitat for a variety of wildlife, but it also aids in reducing soil erosion, protecting water quality and enhancing the aesthetic beauty of a site. Adding native habitat to a solar site can provide benefits to the solar developer (by reducing maintenance costs associated with mowing and spraying around the panels) and to the solar facility's neighbors (by supporting insects that pollinate agricultural crops). Inclusion of extensive pollinator habitat may increase worker safety concerns due to the potential for increased insect stings, so education or avoidance opportunities should be considered.

Monarch Butterfly (Danaus plexippus; Federal Candidate for listing[98])
The monarch butterfly is found in open (field-like) habitats state-wide and relies heavily on a variety of native milkweed species and nectar producing plants. Monarchs can be seen migrating across Georgia in the fall on their way to the mountains of Mexico and before returning to states to the north in the spring. During fall migration, monarch butterflies may roost in large numbers in evergreen trees on cold nights following a day of strong migration. On December 20, 2020, the USFWS determined that listing the Monarch butterfly under the Endangered Species Act is warranted but precluded, meaning that data supports the need to protect this species, but that there are other higher priority species that require attention first. As it is a candidate for listing, the USFWS welcomes efforts to implement conservation measures for this species, and additional details can be found in the Species Status Assessment[99] and the Candidate Conservation Agreement with Assurances.[100] Information on milkweed plants native to Georgia and links to additional resources are also published by the University of Georgia Botanical Garden.[101]

[97] https://www.fws.gov/species/hairy-rattleweed-baptisia-arachnifera
[98] https://www.fws.gov/initiative/pollinators/monarchs
[99] https://www.fws.gov/media/monarch-butterfly-species-status-assessment-ssa-report
[100] https://www.fws.gov/media/nationwide-candidate-conservation-agreement-monarch-butterfly
[101] https://botgarden.uga.edu/wp-content/uploads/2018/03/milkweedinformation.pdf

Conservation Measures for Pollinator Species (including the Monarch butterfly)
1. Create or preserve suitable habitat on idle lands or set-asides in proximity to site. Consider brush removal to promote habitat that can support native milkweed and native nectar-producing plants.
2. Consider planting (recommended) or seeding of native milkweed and native nectar plants with an aim for diversity of species and bloom timing. Organically grown Georgia-sourced plants are preferred. Common milkweed (*Asclepias syriaca*) is not native to Georgia and is an invasive concern, and tropical milkweed (*Asclepias curassavica*) is also not native and potentially harmful to monarch butterflies.
3. When practical, incorporate conservation mowing (i.e., mowing only in early March or in a mosaic pattern) into site maintenance plans to enhance native floral resource habitat while providing cover to overwintering pollinators. If standing vegetation cannot be retained throughout the winter, mow in late fall to leave several inches of vegetation for winter habitat.
4. Utilize targeted herbicide treatments (outside the growing season of native milkweeds) to restore suitable habitat and control nonnative invasive species.

Aquatic Species of Concern

Georgia ranks third in the nation for the number of native species of mussels (127), fishes (265), crayfishes (70), and aquatic snails (84).[102] Five described species are endemic to the state of Georgia and occur nowhere else in the world: Ocmulgee shiner (*Cyprinella callisema*), Altamaha shiner (*Cyprinella xaenura*), Chattahoochee sculpin (*Cottus chattahoochae*), Etowah darter (*Etheostoma etowahae*; Federally Listed: Endangered) and Cherokee darter (*Etheostoma scotti*; Federally Listed: Threatened). Dozens more are nearly endemic and have their range mostly restricted to the boundaries of our state. While Georgia's fish fauna is remarkably diverse, it is also highly threatened. Fifty-eight species are considered imperiled and are protected under Georgia's Endangered Wildlife Act; ten of these fishes are also protected under the U.S. Endangered Species Act. Georgia's fish populations are threatened by a variety of factors including urbanization, land use practices associated with historic and current agricultural and forestry operations, reservoirs, chemical pollution, climate change and invasive species.

Non-point source pollution is not regulated in Georgia, and run-off of sediment, nutrients, and pesticides from various land uses threatens Georgia's sensitive aquatic species including both game fishes (e.g., trout), non-game fishes (e.g., listed darter species), and mussels. These impacts are most extreme in areas where cultivation or development (i.e., urbanization) occurs right up to stream banks or when livestock are allowed access to streams for watering. Sedimentation, which can also result from improper forestry practices or construction activities, decreases water clarity, alters fish and mussel behaviors, and fills in the spaces between larger rocks, which eliminates habitats used for spawning, feeding, and shelter. Nutrient pollution from fertilizer runoff or animal waste can lead to algal blooms, which in turn may affect water clarity and quality as well as impact the condition of aquatic plants that are beneficial to aquatic species (e.g., Riverweed). Developers can help protect streams by maintaining wide vegetative buffers along creeks and streams as well as controlling erosion on project sites.

Conservation Measures for Aquatic Species of Concern
1. Riparian buffers provide habitat for aquatic and terrestrial wildlife and protect water quality by stabilizing stream banks and filtering stormwater runoff. When aquatic species of concern may be impacted, consider increasing vegetative buffers to a 50-ft undisturbed vegetative buffer

[102] https://georgiawildlife.com/georgias-aquatic-species-diversity

	along intermittent streams and ephemeral wetlands, and 100-ft wide buffers along perennial streams and wetlands.
2.	**Implement and maintain best management practices for stormwater management prior to any land clearing, during construction and until final stabilization is achieved and a Notice of Termination is completed.**
3.	**Manage woody species that may shade solar panels with targeted herbicide applications or mechanical- or hand-clearing. If chemicals will be used for site maintenance, direct stormwater runoff to bio-retention areas prior to discharge to streams or wetlands to protect water quality and aquatic and terrestrial wildlife habitats.**

Conservation Measures: Seasonal Considerations for Focal Species

Target Species	Survey Timing	Other Timing Considerations
Gopher tortoise[103]	Burrow status can be easier to visually ascertain during the active season (March – October) but is not limited to this season when burrows are scoped.	• After consulting GA DNR, submit application for Scientific Collection Permit to scope burrows or to relocate/translocate tortoises 4-6 weeks prior to anticipated activity. • Once permitted, burrow scoping should occur during the survey timing period for Eastern indigo snakes of November 1 – March 31. • Permitted gopher tortoise translocations should only occur during late March-May or September-October.
Eastern indigo snake[104]	November 1 – March 31 (Best survey months are December through February)	• Ensure all gopher tortoise burrows (below-ground refugia) are identified prior to implementing Eastern indigo surveys.
Northern long-eared bat[105]	Presence/absence surveys: May 15 - August 15	• Avoid tree clearing between April 1- October 15 when practicable. At a minimum, avoid tree clearing during the non-volant pup season from May 1 - July 31.
Indiana bat	Presence/absence surveys: May 15 - August 15	• Avoid tree clearing between April 1- October 15 when practicable. At a minimum, avoid tree clearing during the non-volant pup season from May 1 - July 31.
Tricolored bat	Presence/absence surveys: May 15 – August 15	• Avoid tree clearing between May 1 - July 31 (full range). • Avoid tree clearing between December 1 and February 28 in counties with year-round populations.

[103] https://www.fws.gov/media/gopher-tortoise-survey-handbookpdf
[104] https://www.fws.gov/media/visual-encounter-survey-protocol-eastern-indigo-snake-drymarchon-couperi-georgia
[105] Protocol for Northern long-eared bat, Indiana bat, and tricolored bat as relevant: https://www.fws.gov/sites/default/files/documents/USFWS_Range-wide_IBat_%26_NLEB_Survey_Guidelines_2023.05.10.pdf

Pollinator species	May – September (timing varies by species)	• Implement mowing in a mosaic pattern in early March (preferred) or sporadically during winter. • Practice targeted herbicide treatments outside the growing/blooming season of desired pollinator species. Timeframe for native milkweed growth and flowering ranges from April to October (species-dependent).
Hairy rattleweed	Stems and leaves are distinctive throughout the growing season. Flowering: late June – early August. Fruiting: August–October	

Summary

PV solar energy is an essential energy resource that provides a variety of important benefits to Georgia. Although potential impacts to wildlife and important natural resources may exist throughout the life cycle of a PV solar facility, these facilities can minimize these impacts or even provide benefits to biodiversity and ecosystem structure and function when sited, developed, and operated responsibly. Solar facilities that are planned with wildlife and other natural resources in mind can help preserve Georgia's tremendous biodiversity and help conserve plants, animals, insects, and the ecosystems they rely upon. Avoidance and minimization practices through proper siting of the solar facilities is a critical first step. Avoiding sensitive areas, known species habitat, and minimizing site disturbance can also save developers both time and money. Site design considerations can protect wildlife movement, provide habitat benefits, and increase community benefits. Finally, incorporating supportive site maintenance and decommissioning practices demonstrates a commitment to avoiding or minimizing impacts and maximizing co-benefits for both human and wildlife communities whenever possible throughout the life cycle of a facility.

Each project has unique siting and design constraints and opportunities, so not every recommendation will be suitable or feasible for every PV solar project in Georgia. Transparent and ongoing conversations between federal and state agencies and the solar development community project experts will continue to be key as trends and practices evolve in the siting and design of PV solar facilities in Georgia and beyond. Agencies like GA DNR, GA EPD, and the USFWS Georgia Ecological Services office can provide site-specific and resource-specific siting and design recommendations which can further minimize impacts and increase co-benefits to wildlife. The renewable energy transition is crucial for both human and wildlife communities, and these RMPs provide voluntary guidance on a wide variety of practices intended to support the growth of solar development while protecting Georgia's incredible biodiversity for future generations.

Additional Resources

Solar Development and Site Selection

- The Chesapeake Bay Foundation. 2020. Principles and Practices for Realizing the Necessity and Promise of Solar Power: https://www.cbf.org/document-library/cbf-guides-fact-sheets/principles-and-practices-for-solar-power.pdf
- The Nature Conservancy in North Carolina. 2023. Principles of Low Impact Solar Siting and Design: https://www.nature.org/content/dam/tnc/nature/en/documents/2023SolarGuidanceTNCNC.pdf
- Innovative Solar Practices Integrated with Rural Economies and Ecosystems (InSPIRE). Aug 2022: https://openei.org/wiki/InSPIRE
- Low-Impact Solar Development Strategies Primer: https://openei.org/wiki/InSPIRE/Primer
- American Planning Association. 2019. Planning for Utility-Scale Solar Energy Facilities: https://www.planning.org/pas/memo/2019/sep/
- Center for Rural Affairs. Clean Energy Policy – Siting Library (Accessed 2023): https://www.cfra.org/cleanenergysiting
- PA Department of Conservation and Natural Resources. 2022. Conservation Considerations for Grid-Scale Solar Systems in Pennsylvania: https://elibrary.dcnr.pa.gov/GetDocument?docId=4659215&DocName=Conservation_Considerations_for_Grid-Scale_Solar_Systems_Pennsylvania_Sept2022.pdf
- Environmental Guidance Document. Georgia Power Company Renewable Development Programs. September 2023: https://resources.georgiapower.com/content/docs/2023_0930_Final_Env_Guidance_Document.pdf

Site Design

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