Report to the Washington State Legislature

Least-Conflict Solar Siting on the Columbia Plateau

June 2023

WASHINGTON STATE UNIVERSITY
Energy Program

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This report can be downloaded at
www.energy.wsu.edu/RenewableEnergy/LeastConflictSolarSiting.aspx

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The **Washington State University (WSU) Energy Program** delivers program management, on-site assessments, analytical tools, and training to meet evolving energy challenges in the State of Washington, the Pacific Northwest, the United States, and internationally.

Partnering with a wide range of agencies, organizations, institutions, and businesses, our energy experts identify energy challenges and develop solutions.

Our customers include large and small businesses, public and private utilities, manufacturing plants, local and state governments, federal agencies and facilities, schools and universities, national laboratories, tribes, professional and trade associations, and consumers.

Our staff of energy engineers, energy specialists, technical experts, and software developers work out of Olympia, Washington. The WSU Energy Program is a self-supported department within the University.

We are part of the College of Agricultural, Human and Natural Resource Sciences (CAHNRS). Our Director reports to the Associate Dean of the College/Director of WSU Extension.

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Table of Contents

Table of Figures

Table of Tables

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Acknowledgements

The Washington State University (WSU) Energy Program acknowledges and appreciates the tremendous effort and consideration that the Conservation Biology Institute (CBI) contributed to the Least-Conflict Solar Siting on the Columbia Plateau project. CBI's director, James Strittholt, and his staff provided technical and geospatial expertise to guide the mapping group participants in implementing the least-conflict concept, resulting in least-conflict solar siting models and maps.

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And finally, a huge thank you and much appreciation goes to the mapping group participants, who gave their time, expertise, and thoughtful deliberation in a collaborative manner to create the least-conflict models and maps.

Photo courtesy of Washington Department of Fish & Wildlife

Executive Summary

While utility-scale solar energy facilities are needed in Washington state to help meet the state's mandate of 100% non-emitting and renewable retail electric load by 2045, where these solar facilities will be sited can be a matter of contention. Since the Clean Energy Transformation Act (CETA) was passed in 2019, solar development companies have shown great interest in building utility-scale photovoltaic farms in the eastern part of Washington state. The eastern part of the state, specifically the sunny Columbia Plateau region, is also home to unique and endangered species and habitat, as well as prime farmland and ranchland. Tribes with reservations within the plateau and other Tribes, including a few located in neighboring states, have rights to use the land for cultural practices, gathering, hunting, and fishing.

Cognizant of the tension between protecting important lands and the need for renewable energy to reduce greenhouse gas emissions (with the goal of lessening the effects of climate change), the Washington State Legislature passed a budget proviso directing the Washington State University (WSU) Energy Program to carry out a Least-Conflict Solar Siting on the Columbia Plateau Pilot Project during fiscal year 2023.

Separate mapping groups representing farmland, ranchland, environmental conservation, and the solar industry met over eight months to create maps on digital platforms that can be used to determine where utility-scale solar development could be potentially sited on the Columbia Plateau with the least amount of conflict. Guided by geospatial analysts, the groups worked with existing data to create models and maps showing the relative values and corresponding conflict levels of farmland, ranchland, and important conservation lands. The solar industry group produced a map identifying lands with differing degrees of suitability for solar photovoltaic (PV) project siting.

A composite dataset, with integrated data from the four individual maps, is one of the main digital end products of the project. The composite dataset is a mapping tool that can produce combinations of different maps with various conflict levels. It is possible, for example, to assess all low-conflict lands with areas of high suitability for solar development. Many other assessments can also be made with different levels of conflict and suitability. The maps provide transparency – characteristics and data that make up the maps are able to be viewed. The information from the composite dataset and other maps could be used by developers to choose sites which avoid impacts and by local governments, state agencies, and organizations as a source of information.

The Columbia Plateau region study area has approximately 14,242,020 acres (not including Tribal reservations). Over 6,777,000 acres were deemed to have high suitability for solar development, and even more were deemed moderately suitable. Of the total study area acreage, just under 212,000 acres – approximately 1.5% of the study area – were deemed low conflict for environmental conservation, farmland, and ranchland, and ranked *"very high," "high,"* and *"moderately high"* for solar development suitability. Low-conflict environmental conservation lands and moderate-conflict ranchlands and farmlands with the same level of solar suitability as the previous example, yields 1,561,700 acres, or 11% of the total study area. More combinations with different suitability and conflict levels can be produced in the mapping programs. It should be noted that specific information about the amount of land needed for solar PV development in order to supply Washington state into the future was not an outcome of this project.

An important note is that Tribes have not approved the maps. Engagement with Tribes was made early in the study process by the project team and continued throughout with discussion on if and how they wanted to be involved. Tribes do not disclose Information about their cultural and natural resource sites on maps because it is sensitive and confidential information and is best protected without disclosing locations. Solar developers must go through the proper process to contact Tribes early in any process and continue engagement throughout.

The intent of the least-conflict solar siting project is to provide an up-to-date source of digital maps that continue to be used. The digital maps reside on the Data Basin Gateway (***https://wsuenergy.databasin.org***), a platform that is open-sourced and free, and that can be used by anyone. Links and Instructions are included in this report. New and updated datasets can be added in the future to keep the mapping tool current. However, there is no funding idenitified for this purpose. Still, it is hoped and expected that this work will assuage some of the tensions in eastern Washington concerning solar siting.

> Separate mapping groups representing farmland, ranchland, environmental conservation, and the solar industry met over eight months to create maps on digital platforms that can be used to determine where utility-scale solar development could be potentially sited on the Columbia Plateau with the least amount of conflict.

Photo by Joanna Cowles; courtesy of Washington State Conservation Commission

Introduction

Legislative Directive

The Washington State University (WSU) Energy Program was directed and funded by the Washington State legislature to carry out a least-conflict solar siting (Least Conflict) pilot project with the goal of identifying areas where there would be the least amount of potential conflict in the siting of utility-scale solar photovoltaics (solar PV) developments[1]. Originally, the project was included as a proviso in the 2020 Washington State Supplemental Budget but was vetoed by Governor Inslee to free up money for pandemic funding. With bipartisan support, the project was reintroduced, and a proviso was included in the 2021 biennium budget, with the work scheduled for the second year of the biennium, July 1, 2022 through June 30, 2023.

Proviso deliverables include a map highlighting areas with the least amount of potential conflict, a report on the project, and a separate compilation of the latest information on opportunities for dual use and colocation of solar PV with other land values, which is sometimes called *agrivoltaics*. This report fulfills the project report deliverable and includes maps highlighting least-conflict areas as well as information on the mapping tool and how it can be accessed and used. The *Least-Conflict Solar Siting* report and report on dual use solar are both available at the Washington State University Energy Program's website: ***www.energy.wsu.edu/RenewableEnergy/LeastConflictSolarSiting.aspx***.

Project Rationale

Since the passing of the Clean Energy Transformation Act (CETA)[2] in 2019, requiring all the state's electric utilities to meet 100% of their retail electric loads using non-emitting and renewable resources by January 1, 2045, many solar developers have been setting their sights on the relatively flat and sunny Columbia Plateau region of Washington state.

1 ESSB 5092, Sec. 607 (19), p. 460 lines 3-13
https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Senate%20Passed%20Legislature/5092-S.PL.pdf

2 *https://www.commerce.wa.gov/growing-the-economy/energy/ceta/*

The region is also home to sensitive and unique habitats and species and has some of the most productive farmland and ranchland in the state. The question that the project set out to answer is:

> Where can utility-scale solar be developed in the Columbia Plateau region while also ensuring that important natural habitat, productive farmlands and ranchlands, and Tribal rights and cultural resources are protected?

Project Approach

The project's main approach was a voluntary, collaborative, non-regulatory effort that engaged relevant stakeholders, Tribes, and key agencies in a conversation and process to identify least-conflict areas for utility-scale solar development. People who work, study, live, and play on, and/or otherwise have a relationship with the land formed mapping groups to create landscape-based models and maps showing the relative values from their perspective of high quality farmland and ranchland, high value environmental conservation lands, and high suitability for PV solar installations. High values for farmland, ranchland, and environmental conservation lands indicate areas of potential high conflict. Conversely, mapping low-conflict lands with high solar suitability indicates areas where utility-scale solar may be developed with the potential for fewer disputes.

A web-based mapping and collaboration platform, Data Basin[4], provided an online workspace for groups to work together to create, review, and revise maps. A customized Data Basin Gateway contains all maps and datasets, as well as other information from the project. This Gateway is a crucial part of the project as it provides the tools for all interested parties, including solar developers, agencies, Tribes, landowners, and non-governmental organizations (NGOs) to continue to access and use the resulting maps and information after the project ends on June 30, 2023. A more detailed description and information on how to use the Data Basin tool is found in **Appendix A**.

The mapping groups were guided in their exercises by geospatial analysts from the Conservation Biology Institute (CBI). CBI used an open-source modeling system called Environmental Evaluation Modeling System[3] (EEMS) to create models from existing datasets and information chosen by the mapping groups. By using the EEMS software, it's possible to view the data and attributes that contributed to the final conflict or suitability level of any spot in each of the final maps. A detailed explanation of the EEMS software can be found in **Appendix B**.

It is important to note that the final composite maps are not intended to determine actual siting of any solar projects, nor to approve or exclude solar projects. The results from the Least-Conflict project are non-regulatory and not subject to adjudication. They are intended to guide large-scale PV solar to areas where there will be fewer objections, where Tribal rights

3 https://consbio.org/publications/a-platform-independent-fuzzy-logic-modeling-framework-for-environmental-decision-support/
4 https://wsuenergy.databasin.org/

and resources are protected, plant and animal habitats and important species unharmed, and prime farmland and rangeland protected. The project also focuses on utility-scale solar, as mandated by the legislature. Other possible locations for solar PV siting, such as under existing power lines, on commercial and industrial facility rooftops, and on parking areas, and disturbed and degraded lands, are not reviewed. The burgeoning arena of dual-use solar, also called *agrivoltaics*, is not explored, though a compilation report on the topic has been produced for the Proviso.

> It is important to note that the final composite maps are not intended to determine actual siting of any solar projects, nor to approve or exclude solar projects.

Three large meetings, called gatherings, were held to (a) kick-off the project and introduce the idea of mapping groups, (b) review the progress of the mapping groups, and (c) provide near-final drafts of the maps. Additional presentations about related topics such as energy transmission and working with Tribes were part of the gatherings. Summaries, presentation slides, and video-recordings are available on the WSU Energy Program Least-Conflict Solar Siting website.[5] All gatherings and mapping groups met via Zoom.

Seven Tribes have reservations or ceded and usual and accustomed lands within the study area. Contact with Tribes was made early on and continued throughout the project to listen to Tribes' concerns and suggestions, and discuss if and how they wanted to participate.

The project was modeled after a similar process called "Solar and the San Joaquin Valley Identification of Least-Conflict Lands Project," completed in 2016, which identified least-conflict lands in the San Joaquin Valley in California. The project's final report, *A Path Forward: Identifying Least-Conflict Solar PV Development in California's San Joaquin Valley,*[6] stated that approximately 5% of the study area amounting to 470,000 acres were identified as least-conflict land potentially available for solar development.

Utility-Scale Solar

This report, by the request of the legislature, is focused on utility-scale PV solar, also known as industrial scale. Solar PV energy is produced when photovoltaic cells convert sunlight into electricity; utility-scale solar uses a large array of solar panels (containing cells) to produce enough electricity to be transmitted into the electric grid. The amount of energy generated by utility-scale PV solar varies; for the purposes of this report it is above 1 megawatt.

5 *https://www.energy.wsu.edu/RenewableEnergy/LeastConflictSolarSiting/gatherings.aspx*
6 *https://www.law.berkeley.edu/wp-content/uploads/2016/05/A-PATH-FORWARD-May-2016.pdf*

As of 2022, the capacity of installed solar in Washington state is over 600 MW, enough to power over 60,000 homes. The capacity of the largest operational solar farm in the state is 150 MW at the Lund Hill project in Klickitat County, which sits on approximately 1,800 acres. Most of the solar projects currently under review or proposed are 80 to 500 MW.

A *Seattle Times* analysis of filings with counties and other documentation, as reported in a May 2, 2021 article, *"Solar farms are booming in Washington state, but where should they go?,"*[7] found that approximately 22,000 acres of solar projects had been proposed up to that date, with nearly all for eastern Washington. Since that time, new projects have been proposed, and some previous projects have not been fulfilled.[8] According to the Solar Energy Industries Association (SEIA), 1 MW of solar PV generating capacity requires five to ten acres of land.[9] A 500 MW solar array, for example, might use up to approximately 5000 acres. Additional land is needed for tying the panels to transmission lines and other equipment, and possibly for battery storage.

7 *https://www.seattletimes.com/seattle-news/environmentsolar-farms-are-booming-in-washington-state-but-where-should-they-go/*
8 *https://www.efsec.wa.gov/energy-facilities*
9 *https://www.seia.org/initiatives/land-use-solar-development#:~:text=Depending%20on%20the%20specific%20technology,(MW)%20of%20generating%20capacity*

Photo by Joanna Cowles; courtesy of Washington State Conservation Commission

The Columbia Plateau

Characterized by low rolling hills for much of its area and a sunny arid climate, the Columbia Plateau covers about a third of the state – most of southeast central Washington, which is part of the larger Columbia River basin. The Plateau is bordered in the north by the Columbia and Okanagan rivers and in the west by the Cascade foothills. It extends south encompassing the Deschutes River in northern Oregon and extends east into Idaho. The Columbia River bisects the plateau.

The Least-Conflict Solar Siting project study area encompasses all or part of 15 Washington state counties: Adams, Asotin, Benton, Columbia, Douglas, Franklin, Garfield, Grant, Kittitas, Klickitat, Lincoln, Spokane, Walla Walla, Whitman, and Yakima (**Figure 1**). The size of the study area is 14,242,020 acres. This total does not include the Yakama Tribe reservation or the part of the Colville reservation that lies within the study area, as these lands have been clipped out of the study.

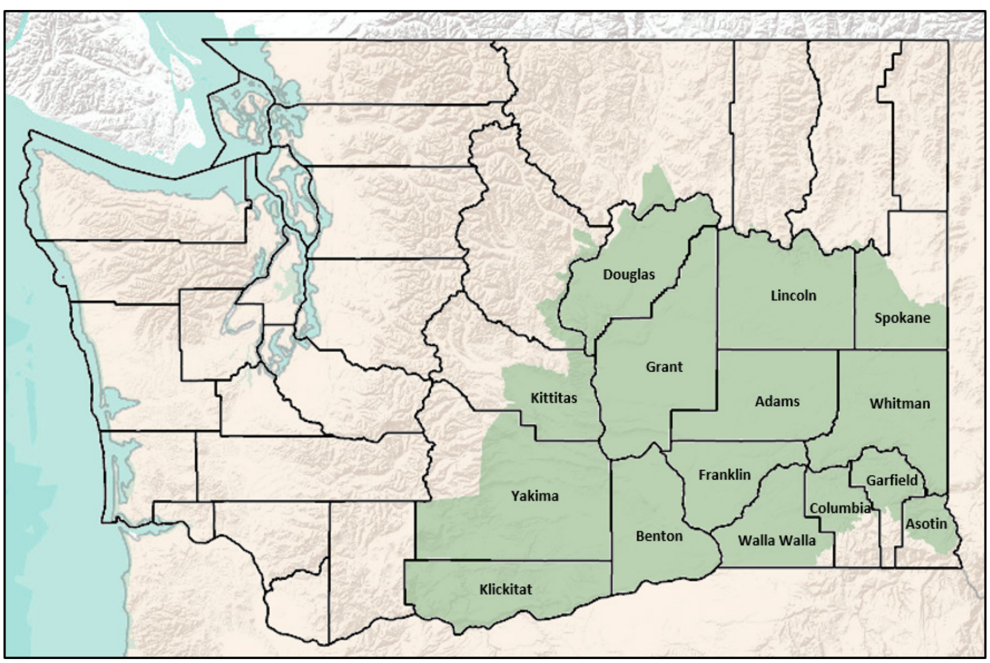

Figure 1. *The Least-Conflict Solar Siting on the Columbia Plateau study area (in green).*

A series of major geologic events created the productive, unique, and diverse Plateau that we know today. The Plateau was built up by successive basalt flows which flowed over the region for millions of years, ending around 6 million years ago. Windblown silt and ash from the Cascades were deposited atop the basalt bedrock and created layers up to two hundred feet thick in the Palouse Hill region. Then, during the last ice age from about 20,000 to 10,000 years ago, a series of huge floods, caused by the breakup of an ice dam which formed Glacial Lake Missoula in Montana, scoured the bedrock and cut deep channels, causing what is known as channeled scablands in part of the region.[10]

The relatively gentle geography and plentiful sunny days of the Plateau contribute to high agricultural productions, great rangelands, and a diverse and unique habitat with associated species, while also making the area attractive for solar development.

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Habitat and Species

The plateau is dominated by shrubsteppe habitat that is rich in biodiversity with unique plants, birds, mammals, amphibians, and reptiles found nowhere else in the state. Approximately 40% of the original shrubsteppe remains, the rest lost or degraded due to agriculture and development. Other natural habitats on the plateau include native grasslands and oak communities, as well as streams and wetlands.[11]

Various groups work, often as partners, to preserve and restore the shrubsteppe, including the Washington Department of Fish & Wildlife, local Tribes, the Arid Lands Initiative, local Audubon chapters, land trusts, and other conservation organizations.

In addition to protecting individual species and habitats, preservation of wildlife corridors is important to allow habitat connectivity so that migrating animals such as elk can thrive.

10 *https://www.nps.gov/parkhistory/online_books/geology/publications/inf/72-2/index.htm*
11 *https://www.nps.gov/parkhistory/online_books/geology/publications/inf/72-2/index.htm*

Farmland

Crop farmland on the plateau can be categorized by irrigated land and non-irrigated land. Irrigation introduced from the creation of the Grand Coulee dam has created the most productive agricultural lands in the state.[12] The deep fertile soils of the Palouse region produce wheat and legumes through dryland farming. The diversity of products grown in eastern Washington also includes a variety of fruits, vegetables, grains, wine grapes, and specialty crops, such as blueberries.[13]

Acreage in farms in the 15 counties within the least-conflict study area totaled over 11 million acres in 2017 according to the 2017 Census of Agriculture conducted by the U.S. Department of Agriculture (USDA).[14] These 15 counties accounted for more than three quarters of the farms in the state. This acreage was also 4.7% less than a decade earlier.

Ranchland

Livestock grazing on open lands such as shrubsteppe is important as it provides many benefits to producers, residents, wildlife, and vegetation. Grazing can manage habitats by controlling the height of invasive plants, spurring the production of nutritious new growth on earlier grazed areas, and encouraging shrub growth. Such grazed lands also have greater plant biodiversity and healthier soil, which in turn benefits wildlife. Grazing encourages conservation on large tracts of land while helping to maintain the unique characteristics of ranching communities. The USDA's Grassland Conservation Reserve Program (CRP)[15] is an example of a unique working lands program which allows producers and landowners to continue grazing and haying practices while conserving grasslands.

The number of cattle and calves in the 15 Columbia Plateau counties was nearly 71% of the total state's share, by 5/8/23 estimates from the USDA National Agricultural Statistics Service.[16]

Columbia Plateau Tribes

The entire Yakama Nation Reservation and part of the Confederated Tribes of the Colville Reservation are located within the project's study area. Outside of the reservations, these two Tribes and five others – Confederated Tribes of Warm Springs, Confederated Tribes of the Umatilla Tribe of Indians, Nez Perce Tribe, Spokane Tribe of Indians, and Kalispel Tribe of Indians – have rights to continue practicing their traditional ways of life on ceded lands and usual and accustomed lands. The Warm Springs Tribe and the Umatilla have reservations in Oregon, and the Nez Perce Tribe Reservation is in Idaho, but their traditional lands encompass

12 https://s3.wp.wsu.edu/uploads/sites/2070/2013/07/ALookWAag2010.pdf
13 https://aridlandsinitiative.org/the-columbia-plateau/
14 https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Washington/wav1.pdf pages 234-239
15 https://www.fsa.usda.gov/news-room/news-releases/2023/usda-announces-grassland-conservation-reserve-program-signup-for-2023
16 https://www.nass.usda.gov/Statistics_by_State/Washington/Publications/Livestock/index.php

part of the Columbia Plateau in Washington state. All these Tribes have lived on these lands since time immemorial and are sovereign, self-governing entities.

The Columbia River Inter-Tribal Fish Commission (CRITFC),[17] formed by The Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Warm Springs Reservation of Oregon, and the Nez Perce Tribe, with the mission of "ensuring a unified voice in the overall management of the fishery resources", also participated in gatherings and meetings.

Engagement with Tribal staff was initiated before the project fully began, and continued throughout, to inform them of the project, listen to their thoughts and concerns, and hear if and how they may want to participate in the project. Separate meetings were held with Yakama, Colville, and Nez Perce, and communication engaged with Umatilla, Warm Springs, and Kalispel. Tribal members attended all three gatherings as well as some mapping groups meetings, especially environmental conservation. Least-conflict project staff gave a presentation on the project at the Nez Perce Tribe Renewable Energy Conference in December 2022, and attended both the eastern and western Washington Tribal/State meetings on Clean Energy Siting in October 2022 in person and on Zoom.

The main results of the least-conflict project are maps, yet Tribes do not disclose Information about their cultural and natural resource sites on maps because it is sensitive and confidential information and is best protected without disclosing locations. Discussion between Tribes and the least-conflict project team often focused on how to protect Tribal rights and cultural resource lands when solar PV is sited, even though information about Tribal land is not included on the least-conflict maps.

Tribes expressed concern that the maps would be misunderstood and give false assurance that Tribes sanction the least-conflict areas. It is important to note that Tribes have not approved the maps, the maps do not replace any "on the ground" surveys, and Tribes must be engaged at the beginning of siting discussions. The project team has included a note in the description of models and map results on Data Basin to this effect.

Another response to concerns by some of the Tribes was to "clip out" the reservations on the maps, so that only the base map, such as topography, is seen (for example, see **Figure 6**). All data used in the project is publicly available. However, when data from different sources are combined in the models, that data is technically new, and therefore could be seen as proprietary when on a reservation; consequently, such combined public data was "clipped out" on the maps for reservations. Also, some of the publicly-available data used in the project is incomplete or missing on reservation lands – clipping out these lands prevents false results.

17 *https://critfc.org/*

It was urged by some Tribes to include irrigation canals as a potential criterion for solar siting. Members of the solar industry mapping group had not considered solar panels over canals in their mapping model. The project team decided to provide a separate dataset layer of the irrigation canals in the study area that can be used with the least-conflict maps. This decision was made in part because the size of canals in comparison to the maps made it difficult to integrate with the models.

A comment from the Confederated Tribes of the Colville Reservation is in **Appendix E**.

Other concerns and suggestions voiced by both Tribal members and others at gatherings and mapping groups are listed below:

- Tribes lack money and staff to deal with all the renewable energy proposals that they must review. This includes Tribal Historical Preservation Officers.
- Tribes lack funding and staff time to attend meetings and respond to the many recent state initiatives, putting them at a disadvantage.
- Solar industry companies do not engage with Tribes early enough. Tribes are often brought in at permitting, after assessment work is done. Tribal engagement should occur before land is assessed or leased.
- Formal tribal consultation is with government, not developers. There is often not enough time in formal decision-making processes for true discussion. Industry talking directly to Tribes is not formal consultation.[18]
- A company should not state that they are aware of traditional properties and cultural sites. There is no substitute for a cultural survey on the ground. At any point during a project, if cultural resources are identified, the companies need to have affirmative outreach and a management plan already in place.
- Some losses due to siting cannot be mitigated. Development should be avoided where cultural and sacred sites cannot be replaced.
- Mitigation agreements may be a way for Tribes to mitigate impacts to cultural and natural resources through the National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA).
- Cultural sites are not protected by some county codes. These may be addressed in long-term planning, but that does not trickle down to decision making.

18 Some Tribes prefer government-to-government consultation, while others allow direct contact by developers. A clause (Section 102 (1)(f) in the 2023 Clean Siting Bill (HB 1216, *https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bills/Session%20Laws/House/1216-S2.SL.pdf?q=20230530172345)* requires the interagency clean energy siting coordinating council to support the Governor's Office of Indian Affairs in creating a list of contacts at federally recognized Tribes, applicable laws on consultation, and Tribal preferences regarding outreach about clean energy project siting and permitting, such as outreach by developers directly, by state government in the government-to-government relationship, or both. More Tribal consultation information can be found at the Washington State Department of Archaeology and Historic Preservation website: *https://dahp.wa.gov/tribal-consolation-information.*

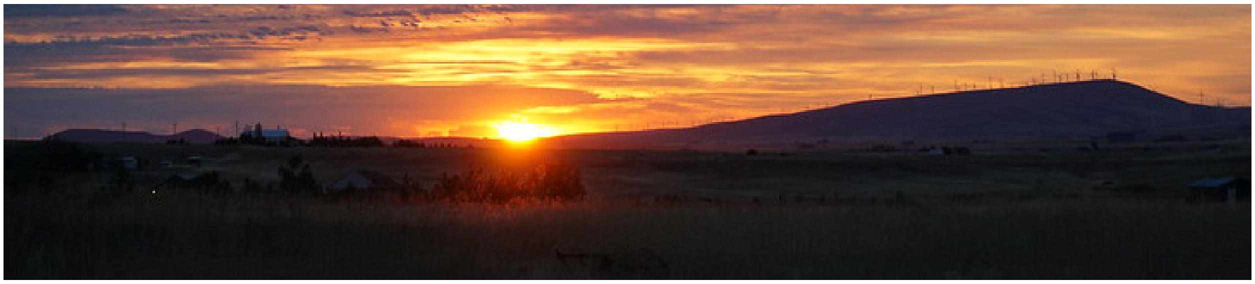

Photo by Kaci Bartkowski; courtesy of Washington State Conservation Commission

Least-Conflict Solar Siting Study Process

The study process focused on small groups who were guided to create maps from their perspective and expertise, and three large meetings – called *gatherings* – that were used to engage the larger audience. The results from the actual mapping process are presented in another section. The timeline of the project is shown in **Figure 2**.

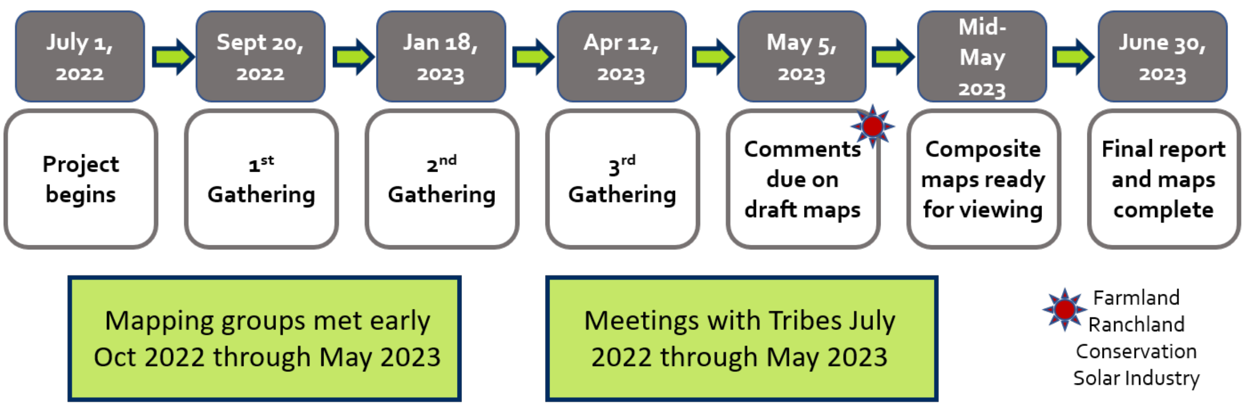

Figure 2. *Least-conflict solar siting project timeline.*

Gatherings

The project team convened three large meetings, called gatherings, open to all interested persons to inform them about the mapping groups and their progress. We also provided information on relevant issues through speaker presentations, and provided opportunities for public participation through audience engagement to obtain feedback on the process.

The kick-off gathering occurred on September 20, 2022, and was used to introduce the least-conflict concept and promote participation in the mapping groups. Participant engagement throughout the day gave attendees the opportunity to voice their concerns and thoughts about least-conflict solar siting, and discuss the criteria that would be useful for creating least-conflict maps.

At the gathering on January 18, 2023, volunteer representatives from each mapping group described their work up to that point and shared draft models and maps. Presentations on related topics were given throughout the day. Liz Klumpp from the Bonneville Power Administration (BPA) gave a presentation to address the question (from the BPA perspective), "Is there transmission capacity to deliver solar power from eastern Washington to loads?" Stew Henderson, from the Energy Facilities Site Evaluation Council, spoke on behalf of the Transmission Corridors Work Group (TCWG)[19] to discuss their findings and recommendations about obtaining more transmission capacity and expediting that capacity increase without compromising environmental protection. Some of the recommendations from TCWG became part of the recently passed Washington state house bill concerning electric power system transmission planning, SB 5165.[20] Dr. Allyson Brooks of the Washington State Department of Archaeology and Historic Preservation (DAHP)[21] shared guidance for working with Tribes, and for identifying and planning around important and sensitive cultural resources in the state. Other presentations included information on the proposed Clean Energy Siting Bill, the Low-carbon Energy Project Siting Improvement Study, and the Nature Conservancy's Power of Place.[22]

Near final drafts of the mapping models, as well as a first look at the composite maps that integrate all maps to find where high solar suitability intersects with the least-conflict areas of the other maps, were the high point of the third gathering on April 12, 2023. Participants were engaged to discuss their observations and insights on the draft maps; many of their comments are listed below, in the next section. Several participants representing different interests, from agencies, conservation NGOs, solar developers, and elsewhere, discussed other ways that they thought the maps could be used. Suggestions included using individual maps to protect natural resources, support communities, start discussions when engaging with Tribes, and more quickly identify high-potential solar development sites.

Summaries, slides from presentations, and video-recordings of the gatherings can be found on the *Gatherings* page[23] of the Least-Conflict Solar Siting website.

19 https://www.efsec.wa.gov/energy-facilities/transmission-corridors-work-group
20 https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bill%20Reports/Senate/5165-S%20SBR%20FBR%2023pdf?q=20230528151603
21 https://dahp.wa.gov/
22 https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_Power-of-Place-WEST-Executive_Summary_WEB-9.2.22.pdf
23 https://www.energy.wsu.edu/RenewableEnergy/LeastConflictSolarSiting/gatherings.aspx

Mapping Groups

Map results and criteria from the four mapping groups are found in the Mapping Results section of this report. This section gives a very brief overview of the mapping groups, and lists comments brought up at gatherings and mapping group meetings.

Four distinct mapping groups were formed and guided by geospatial analysts with the objective to each create landscape-based maps, using available data, to identify relative values from their perspective. The groups generally met biweekly for an hour from October through May. Members of three groups – environmental conservation, farmlands, and ranchlands – were people with knowledge, expertise, and/or experience in those areas relating to the Columbia Plateau. The fourth group, solar industry, was made up of representatives from solar industry with projects or with interest in developing projects on the Plateau, as well as others with related work. All members attended voluntarily, although some may have been involved at the request of their company or agency. Lists of mapping group members are in the mapping results section.

Four distinct mapping groups were formed and guided by geospatial analysts with the objective to each create landscape-based maps, using available data, to identify relative values from their perspective.

A fifth group met a few times to discuss issues concerning how solar siting might affect local communities and economies. It was ultimately determined that creating a cohesive map was not feasible because of the disparate issues that arose, many without datasets. Topics discussed in these meetings included county comprehensive plans and zoning, potential tax burdens on communities hosting projects, and the issue of state versus local control in siting approvals. Datasets pertaining to some local communities and economies issues are included in the Gateway, such as the Washington State Department of Health Environmental Health Disparities, and patterns of population change from the U.S. Census.

Outreach to recruit mapping group participants was aided by various organizations and individuals in their respective fields. For the farmland and ranchland mapping groups, for example, American Farmland Trust reached out to a broad range of agricultural industry groups and commodity commissions. Environmental conservation recruits came from a network of local Audubon chapters and other local organizations, as well as local experts from state agencies such as the Department of Fish & Wildlife. Renewable Northwest, an advocacy nonprofit focusing on renewable energy policies and markets in the Northwest, reached out to their membership, including solar developers and consulting companies, to participate in the solar industry mapping group. Mapping group members also included representatives from county planning departments, conservation districts, and farming and ranching communities.

At the second gathering, mapping group members talked about what they had learned from the processes and the benefits of the collaborative least conflict approach. Some of their comments are summarized below:

- The ability to visualize data through mapping helped the mapping groups "ground truth" members' intuition and site-specific understanding and bring rigor to the process of understanding potential least-conflict areas
- A collaborative approach to the mapping group process helped bring together the knowledge that each member had and test assumptions or subjective ideas that they brought to the table.
- Each group found value in looking forward in time to consider criteria that may influence future land uses. For example, the solar industry group discussed what might change with future locations of substations and transmission and distribution lines. The rangeland group considered future preservation of grazing lands owned by the Bureau of Land Management (BLM)[24] and other entities. The farmland group thought about future water supplies and the potential of bringing irrigation to dryland areas to increase productivity. And the environmental conservation group discussed best opportunities for future expansion of key habitats, and how future climate might shift the locations and movements of species.

The solar industry mapping group was unique in that their objective was to create a map, called a solar development suitability map, showing the relative suitability for solar development based on a number of criteria informed by the available spatial data. The other three mapping groups – farmland, ranchland, and environmental conservation – focused on the relative value of the Columbia Plateau study area, each from their own perspective. Based on specific criteria chosen by each group, three separate maps were created to address the issue of least conflict. Map results from each of these mapping group models could then be applied to the solar development suitability map individually or collectively to obtain different levels of potential conflict. Areas of high solar development suitability and low value (low conflict), from the standpoint of the farmland, ranchland, and environmental conservation mapping groups, signify least-conflict areas for solar siting.

24 BLM is currently conducting a programmatic environmental impact state process for BLM's utility-scale solar energy planning. They are considering including Washington and four other states in this process. *https://www.blm.gov/2023-solar-programmatic-environmental-impact-statement*

Comments and issues expressed at mapping groups meetings and gatherings pertaining to the different mapping groups are summarized below.

Solar

- Lands deemed "disturbed" or "degraded" may be appropriate to use as criteria for determining solar siting, though such lands may be expensive if remediation is necessary.
- Consider using solar over canals as a criterion.
- Storage may affect how much transmission capacity is needed, and when.
- Storage can create permitting issues and influence site selection (siting solar facilities near geographies appropriate for pumped hydro storage).
- It would be helpful to map future transmission capacity as well as the current capacity of substations. The map only reflects current transmission line capacity.
- Local county moratoria on solar development are not reflected on map.
- Maps can be valuable because the data is "crowd-sourced," reflecting multiple perspectives and disciplines.

Farmland

- How will changes in the ability to irrigate in the future, due to drought, affect farming?
- There could be an opportunity to reduce irrigation AND recharge the Odessa aquifer in Adams County, if some of those farms transitioned to solar.
- Water rights and irrigation history map layers would be helpful.
- Farmland connectivity, proximity to infrastructure, and history of farmland use are examples of the types of information necessary to fully understand farming resource lands and how solar development could impact them.
- Include layers that link modeling work with other related activities to help farmers decide which lands are suitable for solar and understand how future climate change may affect those choices.
- The model doesn't compare crop value to potential solar revenue; this comparison should be considered along with topics such as how water availability may change in the region.
- Draft maps can be useful in watershed planning and/or resource inventories.
- The maps could help guide a program to mitigate the loss of land designated for agriculture by enhancing productivity in other areas.

Ranchlands

- Avoid designated rangelands, especially those of long-term commercial significance. Ranchers are concerned they can't competitively lease federal lands for grazing if such lands are made available for leasing to solar developers.
- Fragmenting ranchlands disrupt connectivity for wild herbivores like mule deer. Herbivores are necessary for the health of grasslands. Cattle use ranchlands for a small part of the season while wild animals are always there.
- There is concern that social divisiveness between ranch owners may develop if some owners bring solar siting to the region.
- There is concern about limited water supplies being used for installations.
- There is a need to consider stock that over-winter in lower elevations. Dryland crop stubble is commonly used for livestock.
- Bureau of Land Management (BLM) and Washington State Department of Natural Resources (DNR) lands have higher value on the maps than other lands, but maps don't show specific ownership.

Environmental Conservation

- When siting solar installations, focus on areas that limit impact on water quality, run-off, and riparian zones. Solar development should not exacerbate water challenges through additional withdrawals for construction and the impacts of washing and run-off. Complementary needs like roads and vegetation control can also degrade water resources.
- There are concerns about the scale of potential solar development in a shrubsteppe environment.
- It is important to maintain ecological connectivity and migration corridors.
- Impact to habitat and species should be minimized by developing on degraded or developed lands such as brownfields and sites already developed for other uses, like transmission line corridors.

Other Comments

- Address and avoid unequal benefit to communities hosting a project. The value of solar equipment depreciates over time on public lands and can become a tax burden.[25]
- Avoid siting within city limits, urban growth areas, and rural activity centers; understand how local governments define areas for planning and zoning.
- There is a disconnect between the way the maps reflect land value and the way Washingtonians will likely interpret the value of their land. The maps do not show us how people living in areas identified as least-conflict will feel about solar development.
- Conservation Reserve Program (CRP) lands are important resources across all mapping groups.
- It is important to understand lands and species and other factors that are important to Tribes.
- There is a "Cascade divide," with some concern about the urban west using power generated on the east side of the state.
- Strengthen monitoring and enforcement of adaptive management on developed sites to ensure compliance with mitigation and other requirements.
- Use agrivoltaics and other new technologies and solutions (rooftop solar, reduce utility-scale).
- There is tension between how different groups view agricultural and natural lands. There is some public opposition to developing even marginal agricultural lands, which can increase the pressure to use natural areas instead.
- Ensure that site design minimizes impacts. For example, fencing and the arrangement of solar panels can help animals move through sites.
- Plan for end-of-life issues for solar installations. Have plans for disposition of sites when facilities are retired or not needed and for recycling panels.
- Make sure to have a mitigation plan. If there is no mitigation plan, then no permit.
- Consider creating layers that show the feasibility of dual-use solar.
- Consider marginal and/or fire-prone lands for solar.
- Minimize the impacts of solar on water quality and quantity.
- What are the forecasts for the amount of solar power generation needed to meet state goals, and what are the expected sizes and acreages needed to achieve this?
- Be aware of and heed the Healthy Environment for All (HEAL) Act.[26]

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25 SHB 1756 supports clean energy through tax changes by providing tax incentives for communities siting solar projects and eliminates the depreciation effect of property taxes over time.
https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bills/Session%20Laws/House/1756-S.SL.pdf?q=20230621150720.pdf

26 The HEAL Act, passed by the Washington State Legislature in 2021, provides a framework for equitable community engagement and public participation and consideration of environmental justice.
https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Session%20Laws/Senate/5141-S2.SL.pdf

Photo by James Riser; courtesy of Washington State Conservation Commission

Related Clean Energy Efforts, Regulations, and Tools

This section describes a few of the regulations, processes, and tools that are relevant to clean energy efforts, and in particular solar PV. For a more in-depth list and description please refer to the Regulatory Context section of the *Low-Carbon Energy Project Siting Improvement Report*,[27] pages 28 through 43, produced by the Washington State Department of Ecology and the Washington State Department of Commerce in November 2022.

The Washington state government is committed to lessening the impacts of climate change by transitioning to a clean energy future and reducing greenhouse gas emissions (GHG). To this end, various legislation has been passed to reduce GHG and promote electrification of the energy, building, and transportation industries. There are regulations to shift utility loads to non-emitting and renewable resources (Clean Energy Transformation Act),[28] implement a cap-and-invest program (Climate Commitment Act),[29] require cleaner fuel (Clean Fuel Standard),[30] promote electric vehicles, and reduce building energy use (Clean Buildings Performance Standards).[31] To work toward equitable sharing of environmental benefits for overburdened communities and vulnerable populations, including Tribes, the HEAL Act[32] was passed in 2021. The HEAL Act directs covered agencies to create and adopt a community engagement plan that includes the use of special screening tools that integrate environmental, demographic, and health disparities data.

Clean Energy Transformation Act

In particular, the Clean Energy Transformation Act (CETA) (SB 5116, 2019) has stimulated increased interest in solar developments in Washington state. CETA, which was passed by the Washington State legislature in 2019, requires all the state's electric utilities to meet

27 https://apps.ecology.wa.gov/publications/documents/2206013.pdf
28 https://www.commerce.wa.gov/growing-the-economy/energy/ceta/
29 https://ecology.wa.gov/Air-Climate/Climate-change/Reducing-greenhouse-gases/Climate-Commitment-Act
30 https://ecology.wa.gov/Air-Climate/Climate-change/Reducing-greenhouse-gases/Clean-Fuel-Standard
31 https://www.commerce.wa.gov/growing-the-economy/energy/buildings/clean-buildings-standards/
32 https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Session%20Laws/Senate/5141-S2.SL.pdf

100% of their retail electric load using non-emitting and renewable resources by January 1, 2045. The law prescribes a stepped process. Coal-fired resources must be eliminated by December 31, 2025. and all retail sales of electricity must be GHG neutral by January 1, 2030. Safeguards have been written into the law, such as requiring the equitable distribution of clean energy transition benefits and the expansion of energy assistance programs for low-income customers. Along with increased siting of renewable energy projects, the law is expected to increase pressure for increased electric transmission capacity.

Project Proposals and Siting Reviews

Solar developers may choose to use the State of Washington Energy Facilities Site Evaluation Council (EFSEC)[33] to coordinate and review project proposals, or they may go through the local government where the facility will be located. The recently passed Clean Energy Project Siting bill (HB 1216, 2023)[34] establishes an option for solar energy developers to use a coordinated permit process led by the Washington State Department of Ecology.

EFSEC coordinates environmental evaluations and consolidates the permitting steps. While certain facilities such as some electrical transmission facilities and nuclear power plants are required to use the EFSEC process, facilities that use alternative energy resources exclusively, such as solar, may opt-in to use the EFSEC process. For a list of state permits that a clean energy project may need, see Table 2 on pages 36-37 of the *Low-Carbon Energy Project Siting Improvement Report.*[35]

If not going through EFSEC, county planning departments coordinate the process for solar developers. The county ensures that the project complies with local plans and regulations, which may include comprehensive plans and critical area and zoning ordinances; in addition, the county planning department is usually the lead for state environmental reviews.

Comprehensive plans are the central part of the planning process for the state's Growth Management Act (GMA),[36] which requires certain counties, dependent on size, and cities within those counties to adopt regulations to manage growth and development. Some of these regulations include protecting critical areas, and natural resource, agricultural, and forest lands, implemented through zoning.

33 *https://www.efsec.wa.gov/*
34 *https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bills/Session_Laws/Housee/1216-S2.SL.pdf?q=20230530172345*
35 *https://apps.ecology.wa.gov/publications/documents/2206013.pdf*
36 *https://www.commerce.wa.gov/about-us/rulemaking/gma-laws-rules/*

Some participants at the Least-Conflict gatherings and mapping groups expressed the following concerning the choices that solar development companies have for applying for project approval in Washington state:

- Concern that a proposal would be fast tracked if it went through EFSEC.
- GMA lands and current resource land designations (specifically non-agriculture uses) do not necessarily align with lands being designated for solar siting. Some counties don't allow for conditional use, and changing the designation of these areas is extremely difficult.
- Concern about the intersection of solar siting with GMA's Voluntary Stewardship Program (VSP). If current farmlands are re-designated for solar development, they are no longer considered a resource land and VSP no longer applies.
- Selling or leasing land for solar development because of the economic reality of farming and increased land values is appealing to farmers.

Low-Carbon Energy Project Siting Improvement Study

An initiative to develop recommendations for potential improvements to the siting and permitting of industrial low-carbon projects and facilities in Washington was carried out in 2021 and 2022 by the Washington State Departments of Ecology and Commerce. Although the Low-Carbon Energy Project Siting Improvement Report was submitted before the Least-Conflict study was completed, some of the report's recommendations include future uses of the Least-Conflict study's results:

- Consider incentives to develop projects at sites identified through least-conflict studies.
- Conduct additional least-conflict mapping for specific geographic areas or energy types.
- Develop guidance on how local governments can utilize least-conflict processes and upfront planning to provide information and reduce timelines for the review and permitting of projects.

Other Clean Energy Mapping Efforts

A few other clean energy mapping projects were completed before the results of the least-conflict process were available. When possible, data and information was shared with these other projects, which all had at least a slightly different purpose.

- **Washington State Compatible Energy Siting Assessment (CESA) Site Consultation Tool Prototype**[37]
  - The Prototype tool is a consultation platform that promotes early and ongoing civilian and military coordination.
  - This tool was developed by the Washington State Department of Commerce in partnership with EFSEC and the Utility and Transportation Commission (UTC), with funding support from the Department of Defense Office of Local Defense Community Cooperation.

37 *https://cesa-timmons-group.hub.arcgis.com/*

- **Department of Natural Resources (DNR) Clean Energy Map**[38]
  - This is an interactive map that shows site characteristics and lease expiration information for state trust lands that DNR would consider leasing for clean energy project development.
- **The Nature Conservancy: The Power of Place – West**[39]
  - This study identifies optimal pathways to reach net zero emissions by 2050 across eleven Western states, including Washington. The study estimates the land required and energy capacity needed by modeling scenarios such as high electrification and renewables only.

Related Bills Passed in 2023

Results and recommendations from Initiatives and studies such as the Low-Carbon Energy Project Siting Improvement study, the Transmission Corridors Work Group, and the Least-conflict Solar Siting study led to new and amended bills in the 2023 Washington State Legislative session.

Clean Energy Project Siting

Governor Inslee signed the Clean Energy Project Siting bill (HB 1216, 2023)[40] into law on May 3, 2023, effective July 23, 2023. This new law takes into account some of the recommendations from the Low-Carbon Energy Project Siting Improvement study to improve permitting of renewable energy projects, and also includes reference to the least-conflict solar siting project. Among other items, the law establishes an Interagency Clean Energy Siting Coordinating Council, directs the Washington State Department of Commerce to establish a new program for the designation of Clean Energy Projects of Statewide Significance, directs the Washington State Department of Ecology to prepare non-project environmental impact statements (EISs) for solar energy projects and other clean energy enterprises, and establishes an optional coordinated permit process for clean energy projects. In particular, non-project EISs for utility-scale solar energy projects will consider the findings of the WSU Energy Program's least-conflict solar siting process. The bill also directs the WSU Energy Program to conduct a siting information process for pumped storage projects in Washington.

Electric Power System Transmission Planning

The newly amended sections of this law (SB 5165, 2023)[41] were written in response to the recommendations made by the Transmission Corridors Work Group to improve transmission planning efforts in preparation for 100% clean energy in the state by 2045.

38 https://www.dnr.wa.gov/cleanenergymap
39 https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_Power-of-Place-WEST-Executive_Summary_WEB-9.2.22.pdf
40 https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bills/SessionLaws/House/1216-S2.SL.pdf?q=20230530172345
41 https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bills/SessionLaws/Senate/5165-S.SL.pdf?q=20230530174136

Photo by Ferdi Businger; courtesy of the Chelan-Douglas Land Trust.

The Mapping Process

Washington Columbia Plateau Least-Conflict Solar Siting Gateway

One of the important aspects of the least-conflict process was to create an online workspace from which participants could explore spatial datasets relevant to the goals of the least-conflict project, allowing them to work together in private working groups to create maps showing relative solar development suitability or potential conflict based on the perspectives of each group. This was achieved by creating a customized Data Basin Gateway dedicated to the project (***https://wsuenergy.databasin.org/***).

Data Basin is a web-based mapping and collaboration platform developed by the Conservation Biology Institute and publicly launched in 2010. Data Basin is a highly sophisticated system that meets many scientific and technical demands; it was also developed to be effectively used by a wide range of users. A person does not need to be a mapping professional to use Data Basin, which makes it ideal for supporting a process such as least-conflict mapping.

The core of Data Basin is free to visitors and provides open access to thousands of high-quality biological, physical, and socioeconomic datasets. This user-friendly platform enables people with varying levels of technical expertise to:

- More easily find map data of interest
- Upload their own map data
- Explore and organize map data in new ways
- Create new maps
- Publish or produce new datasets and maps
- Work together in self-organizing groups

To support the process of defining least conflict lands for utility-scale solar development, over 650 individual datasets were aggregated into the customized Gateway. This customized Gateway can be used anonymously, but users must create a free personal account in order to take full advantage of the system (see **Appendix A** for more information about Data Basin and how to create your own user account).

The landing page (**Figure 3**) is organized to help users find and use relevant map-based content as efficiently as possible. The top of the page contains a series of five drop-down menus that provide system-level content (including tutorials and FAQs). The center of the page presents four links (or galleries) pertaining to the four mapping groups – solar industry, environmental conservation, ranchlands, and farmlands – as well as one link containing other popular datasets. Not all of the content in the Gateway is assigned to these five galleries. The remaining content can be located using browse or search functions provided in the system. The next level down on the landing page is composed of three panels, including a Project Description, Quick Start Map, and a carousel of Featured Content (e.g., final models from each of the working groups).

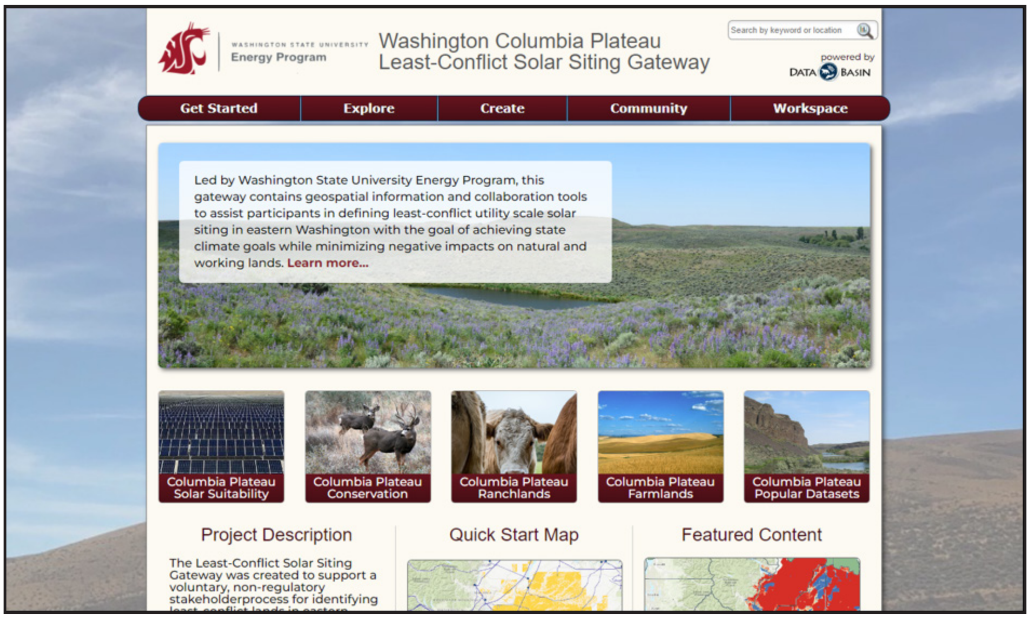


Figure 3. *Image of the Washington Columbia Plateau Least-Conflict Solar Siting Gateway landing page.*

Early in the process, the online mapping system was instrumental in supporting the members of the four mapping groups as they reviewed potential datasets for use in their respective models. Having the ability to review the data as a group was invaluable as it clarified for everyone the value and limitations of the data in-hand while illuminating important data gaps. A group on Local Communities was also originally created and its members relied on the system to explore spatial data relevant to the socioeconomic data and information available for the region. After several highly informative meetings, this group decided that a map-based model would not be feasible given the lack of inconsistant local datasets. Rather, informative spatial datasets were identified and uploaded into the system to be used in conjunction with the various model outputs and other ancillary datasets in the Gateway. Many of these are included in the Columbia Plateau Popular Datasets link on the Data Basin homepage.

All of the content used in or generated from the mapping process can be obtained from the Gateway where it will remain into the foreseeable future.

All of the content used in or generated from the mapping process can be obtained from the Gateway where it will remain into the foreseeable future. Going forward, updated or new content can be added to the Gateway by any registered user in order to support ongoing or future planning in the region. Anyone may register on the Data Basin website for free.

Map Data

To support the project and enrich the online data library, over 665 individual datasets were acquired and curated in the Gateway. Managing spatial datasets is challenging as there are many important issues to consider:

- locating authoritative sources
- evaluating data quality
- understanding data timeliness
- acknowledging data complexity
- describing data properly (or creating metadata)
- dealing with data sensitivities

With support from our project participants, we were able to acquire and include many highly valuable datasets relevant to the purposes of the least-conflict process. In particular, many state agencies were extremely helpful in obtaining critical datasets while working with us to simultaneously protect the sensitive nature of many of them. We also had to keep an eye out for new versions of key datasets, a task at which we were successful. One of the advantages of maintaining the Gateway beyond the life of this particular project is that members of the community can upload new or updated datasets on their own.

Fuzzy Logic Modeling

The Environmental Evaluation Modeling System (EEMS) is the open-source fuzzy logic modeling system developed by the Conservation Biology Institute (Sheehan and Gough 2016)[42] that was used to produce all of the group models in support of the project. Fuzzy logic is a powerful modeling approach that is well-suited for addressing complex, map-based questions (Zadeh, 1973)[43] and has been successfully applied in a variety of environmental and natural resource contexts (Bojorquez-Tapia, et al. 2002; Boclin and de Mello 2006).[44, 45] The main principle behind the term fuzzy is that at some point in the model, all inputs are defined along a numeric true-false continuum; in the case of EEMS, True = +1.0 and False = -1.0. Therefore, it is not uncommon to see map labels used with qualifiers such as "High," "Low," "Good," etc. This method is superior to binary (Yes/No) modeling approaches, especially when considering numerous mapping criteria to address complex questions. This approach offers two main advantages:

- It allows for the integration of any spatial data regardless of the type of attribute being evaluated.
- It provides a high level of precision to explain the logical relationship of each input to other data.

EEMS relies on a tree-based logic modeling framework that combines any number of spatial datasets (map inputs) into a logical arrangement that addresses hierarchical, interrelated relationships to answer a key question as a final map (**Figure 4**). An important feature of the EEMS modeling software is that all map panels (or nodes), regardless of where they occur in a designed tree diagram, can be easily viewed and explored, thereby avoiding the problem of the more common black-box modeling approaches. Another advantage of the EEMS approach is that updates to specific datasets can be included in future versions with minimal effort. Finally, this open-source software is highly transparent and can involve non-technical users in the modeling process.

It is important to note that not all numeric values for map panels in an EEMS model fall between +1.0 and -1.0. This range of values applies only for the map panels where the fuzzy or true/false continuum is employed. For each mapping group's model diagrams, all gray panels are classified as raw data and the numeric values have a range most applicable to that data. In the model diagrams, all sections that show a gray panel transitioning to a blue panel depict where the raw data values are converted to the fuzzy true/false continuum.

42 Sheehan, T. and M. Gough. 2016. A platform-independent fuzzy logic modeling framework for environmental decision support. Ecological Informatics, 34(2016):92-101. *https://consbio.org/publications/a-platform-independent-fuzzy-logic-modeling-framework-for-environmental-decision-support/*

43 Zadeh, L., 1973. Outline of a new approach to the analysis of complex systems and decision processes. IEEE Trans. Syst. Man Cybern, 3:28-44. *https://ieeexplore.ieee.org/document/5408575*

44 Bojorquez-Tapia, L.A., Juarez, L., Cruz-Bello, G., 2002. Integrating fuzzy logic, optimization, and GIS for ecological impact *aaassessments. Environmental Management, 30:418-433. https://www.academia.edu/4762651/Integrating_Fuzzy_Logic_Optimization_and_GIS_for_Ecological_Impact_Assessments*

45 Boclin, A., de Mello, R., 2006. A decision support method for environmental impact assessment using a fuzzy logic approach. *Ecological Economics, 58:170-181. https://econpapers.repec.org/article/eeeecolec/v_3a58_3ay_3a2006_3ai_3a1_3ap_3170-181.htm*

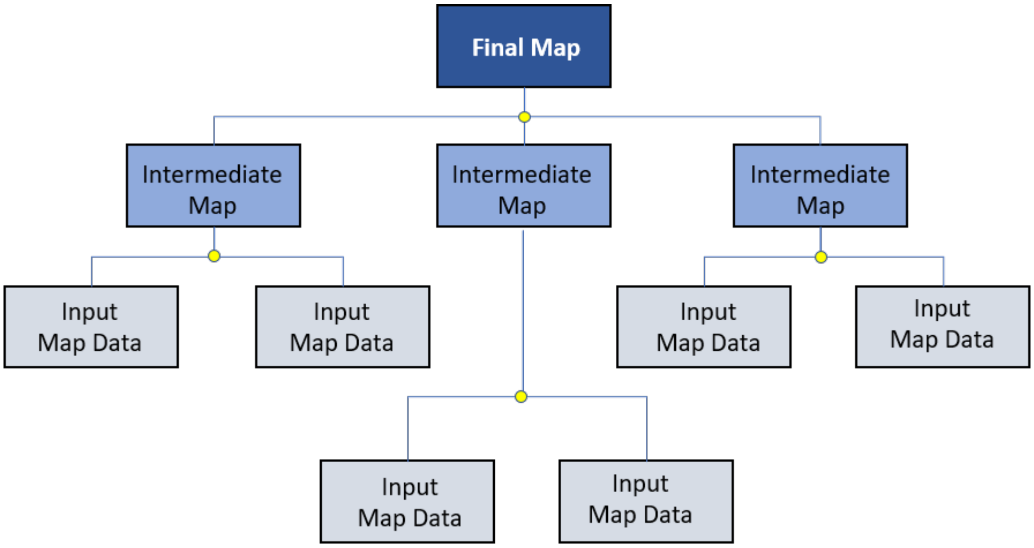


Figure 4. *Generalized EEMS tree-diagram showing a series of map panels (or nodes).*

The intent for each mapping group was to create the most meaningful model and map results possible. Model resolution chosen for all mapping groups was a 500-meter grid, which is approximately 62 acres. Group work began with a review of an EEMS primer that included a description of the main model features (see **Appendix B**). Then groups reviewed extensive spatial data which was loosely informed by the main criteria each group identified for their respective models. For example, criteria for the ranchland model included: (1) access to water by livestock, (2) natural forage condition, (3) physical growing environment, and (4) current managed ranchlands. From the collected spatial data, those best suited to inform each criterion in the model were selected. The next task for each group was to begin building a logical tree-diagram based on the high-level criteria and available datasets with the goal of generating a final map that answered the main goal. In the case of the ranchland model, the main goal was to produce a map that illustrates the relative value of ranchlands based on available spatial data for the Columbia Plateau in Washington state.

Throughout the EEMS model building exercise, mapping group participants provided guidance via a series of model iterations with the objective being to test all aspects of the model (overall design, criteria, input data, and model controls) to produce the most useful end products. This process was assisted by providing participants with direct access to the draft models between meetings using an online application called EEMS Online (***https://eemsonline.org/***), where participants could explore all details of the models on their own time and explore logic operators, input thresholds, and weighting to test various assumptions and gain a better understanding of the model. Numerous revisions were made based on participant comments throughout the process to create the final models and the maps generated by the models. These were uploaded into the project gateway on the Data Basin platform so that they could be used together and in conjunction with additional datasets in the system.

Photo courtesy of the Washington State Department of Commerce.

Mapping Results

Solar Industry Mapping Group

The goal of the solar industry mapping group was to produce a map that illustrates the relative suitability of lands for utility-scale solar development based on general, mappable criteria.

Solar Development Suitability Model Structure and Description

The solar development suitability model is composed of four main branches: (A) Good Terrain Suitability, (B) Low Hazards, (C) Close Proximity to Infrastructure, and (D) Exclusion, which is near the top of the diagram (**Figure 5**). A total of 13 different inputs from eight different sources were included in the model. In most instances a single dataset was included as a single input. However, the relationships between data sources and model inputs were sometimes less straightforward. For example, the roads input layer for this model was created by merging three datasets into one (see model reference 6 in **Table C-1** in **Appendix C**). In other cases, subsets of a single dataset were split to create separate model inputs (e.g., transmission lines of different capacities). In still other cases (e.g., wildfire), multiple datasets were merged together and then two model inputs (wildfire density and wildfire count) were derived from the combined dataset.

A. **Good Terrain Suitability** was created from two inputs – Favorable Slope & Aspects and Favorable Substrate (Soils). For the former, all northern exposures (north, northwest, and northeast) were given a totally false value (-1) with the remaining areas prioritized by percent slope. The most favorable slope areas (totally true) were flat (identified as +1), with slopes getting progressively less optimal as slope increased to 8% at which point all slopes were assigned -1 (totally false). Favorable Substrate was defined by two inputs – Low Mean Percent Rock (defined by a range from 0% most favorable up to 20% at which point all higher values received a value of -1) and Low Mean Percent Clay defined by a range from 0% most favorable up to 25% at which point all higher values received a value of -1. The logic justification is that solar construction is more difficult on very rocky or heavy clay soils. For this node of the model, the Favorable Slope & Aspects map accounted for 70% (0.7 weight) of the WEIGHTED UNION while Favorable Substrate contributed 30% (0.3 weight).

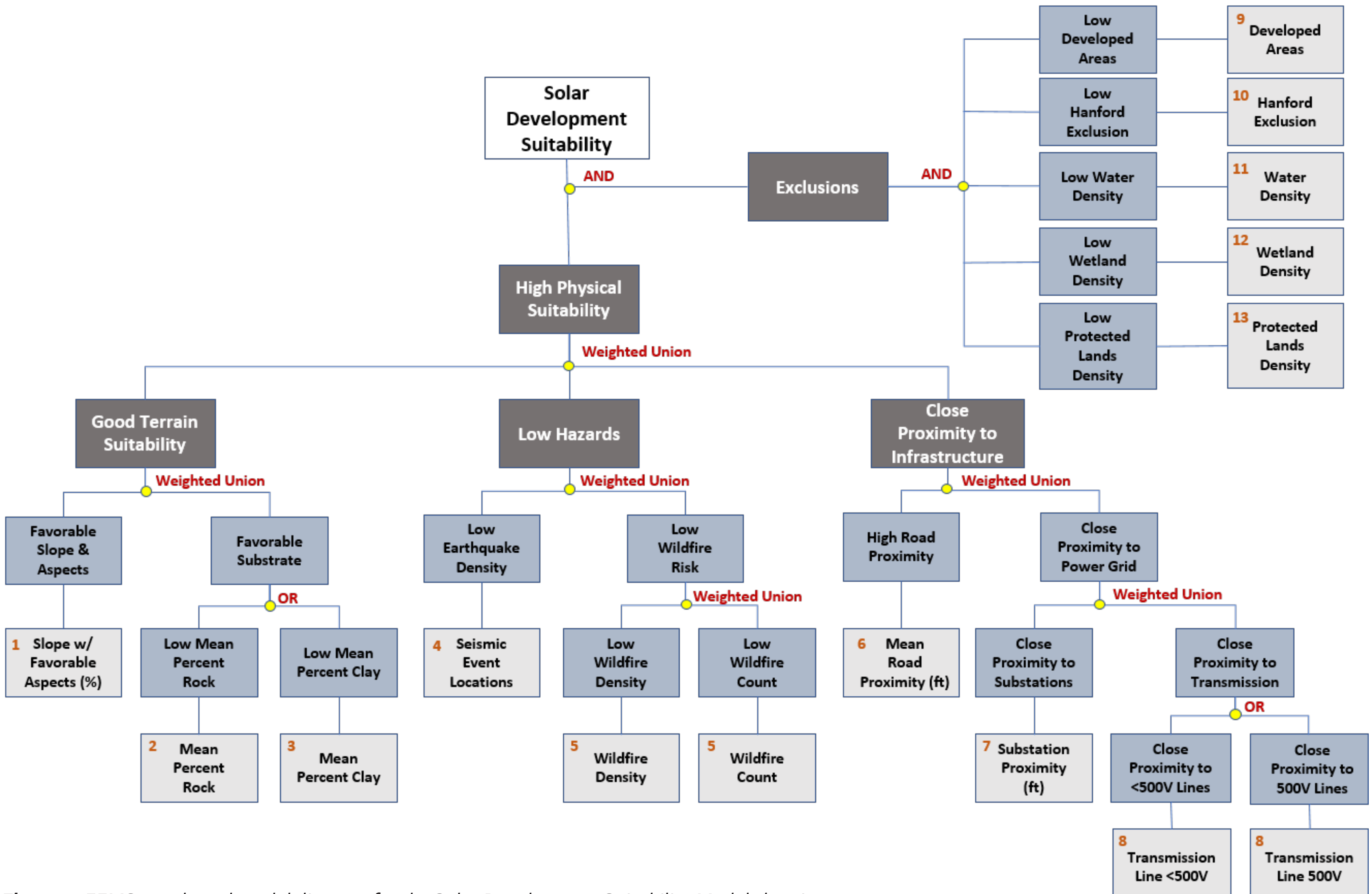


Figure 5. *EEMS tree-based model diagram for the Solar Development Suitability Model showing individual model inputs (gray boxes), intermediate map after fuzzy command (blue boxes), high-level nodes (dark gray boxes with white text), and apex map (white box at the top of the diagram). Logic operators are indicated in dark red text (see Appendix B for operator descriptions). Orange numbers in the gray boxes correspond to the data sources in* ***Table C-1*** *in* ***Appendix C****.*

Solar Development Suitability Model Inputs

USDA Natural Resources Conservation Service
- Percent Rock
- Percent Clay

Washington Department of Fish & Wildlife
- Wetlands

U.S. Geological Survey
- National Land Cover (2019)
- National Hydrography Dataset
- Protected Areas Database

Washington State Department of Transportation
- Highways
- State Routes
- Other Routes

Washington State Department of Commerce
- Electric Substations
- Electric Power Transmission Lines

Washington Geological Survey
- Faults and Earthquakes

Multi-Agency
- Aspect-Slope
- Wildfire Perimeter History
- Wildfire History Current Decade

Bechtel Hanford, Inc.
- Hanford Land Use Designations

B. The **Low Hazards** node was created from two factors – Low Earthquake Density and Low Wildfire Risk. Earthquake Density was informed by the Seismic Event Locations dataset from the Washington Geological Survey, which contains information about all earthquakes between 1970 and 2011. Earthquake damage in the study area has been minor, but a number of active faults persist. Low Wildfire Risk was composed of recent wildfire perimeter data from two sources. From these combined datasets, wildfire density and count (occurrence and frequency) were mapped and included in the model. The Hanford area showed the greatest wildfire impacts in the study area, but a few other locations were also identified. The Low Hazards node of the model was a WEIGHTED UNION dominated by Low Fire Risk (0.7 weight) versus Low Earthquake Risk (0.3 weight).

C. **Close Proximity to Infrastructure** was created from two inputs – High Road Proximity and Close Proximity to Power Grid. Multiple road datasets were combined and incremental distance away from roads was calculated, since close proximity to roads is advantageous to potential development. The threshold for this input ranged from 0 (+1) to 26,400 feet (5 miles, -1). Proximity to existing substations was defined the same as for roads. Transmission line data was split into two files based on line capacity: (1) 500 v class and (2) lines less than 500 v. Maximum distances were defined as 52,800 feet (10 miles) for the higher line capacity and 26,400 feet (5 miles) for the lower line capacity. Close Proximity to Power Grid prioritized proximity to substations slightly more than proximity to transmission lines, with 0.55 and 0.45 weighting, respectively. Close Proximity to Power Grid (0.7) was weighted over High Road Proximity (0.3) in a WEIGHTED UNION to form the Close Proximity to Infrastructure node in the model.

High Physical Suitability was created by integrating the main branch outcomes in a WEIGHTED UNION. Good Terrain Suitability and High Proximity to Infrastructure were equally weighted (0.45 each) and Low Hazards only minimally included (0.1).

D. The **Exclusions** node was composed of five components: (1) Developed Areas, (2) Hanford Exclusion, (3) Water Density, (4) Wetland Density, and (5) Protected Lands Density. For exclusion purposes, Protected Lands included all fee and conservation easement areas (GAP Status 1 & 2)[46] plus the Yakima Firing Center. In order to indicate these areas as the lowest solar development suitability (-1) in the final map, the composite Exclusion map node was combined using the AND operator and then added to the High Physical Suitability node using another AND operator. All exclusion areas are represented as a -1 (green-colored areas on the map).

As discussed in the Columbia Plateau Tribes section, the solar development suitability model does not include irrigation canals as a substrate. This is not meant to infer that solar PV cannot be built there. Due to the small size of the canals compared to the project's 500m grid size, and that discussion occurred late in the process, a separate dataset was instead created from the National Hydrography Dataset (NHD) water flowlines data and can be accessed in the Gateway (***https://wsuenergy.databasin.org/datasets/4d019a151745414f9c253487bf9cb477/***).

Solar Suitability Model Inputs

All data inputs included in the model are listed in **Table C-1** in **Appendix C**, which includes model reference numbers, dataset titles, source(s), and Gateway links. Links to all model data sources can be accessed in the Gateway from a single link (***https://wsuenergy.databasin.org/galleries/2f5dc5659ff646ffa 272802d05137e4f/#expand=352643***).

Solar Suitability Model Results

The Final Solar Development Suitability map for the Washington Columbia Plateau is presented in **Figure 6**, with the corresponding summary statistics for the eight-class numeric bins displayed on the map provided in **Table 1**. Highest value areas, indicating high suitability for solar development, are shown as purple and least value areas are shown in green. The highest value areas are closest to existing infrastructure (transmission lines, substations, and road access). Summary results can also be viewed in a more continuous fashion in a histogram (**Figure 7**), which provides a more granular view of the results. The histogram is best

46 GAP status is the measure of management intent to permanently protect biodiversity. See Scott, J.M., F. Davis, B. Csuti, et al. 1993. Gap Analysis: A Geographic Information Approach to Protection of Biological Diversity. Wildlife Monographs, No. 123. 41pp. *https://www.jstor.org/stable/pdf/3830788.pdf*

viewed with Table 1. Each cell in the histogram corresponds to one of the 230,542 500-meter (approximately 62 acres) grid cells on the map (**Figure 6**). Rather than viewing the results as eight standard categories (or ranks), the actual cell counts are presented. The highest cell count along the continuum was for -1.00, which was largely due to existing protected areas, Hanford, and the Yakima Firing Center. The highpoint of the histogram shows that, outside of the protected areas, the greatest number of cells, or acres, corresponds with the moderately high suitability rank, with a score of 0.25-0.50.

A diagram showing various map panels can be viewed in **Appendix D**. All map panels in the Solar Development Suitability model can be viewed and fully explored in the Gateway by opening the file called **High Solar Development Suitability EEMS Model, Washington Columbia Plateau – Least-Conflict Solar Project** and clicking the EEMS Explorer icon (***https://wsuenergy.databasin.org/datasets/29bee0630f914b829d94a9dbab50fa9c/***).

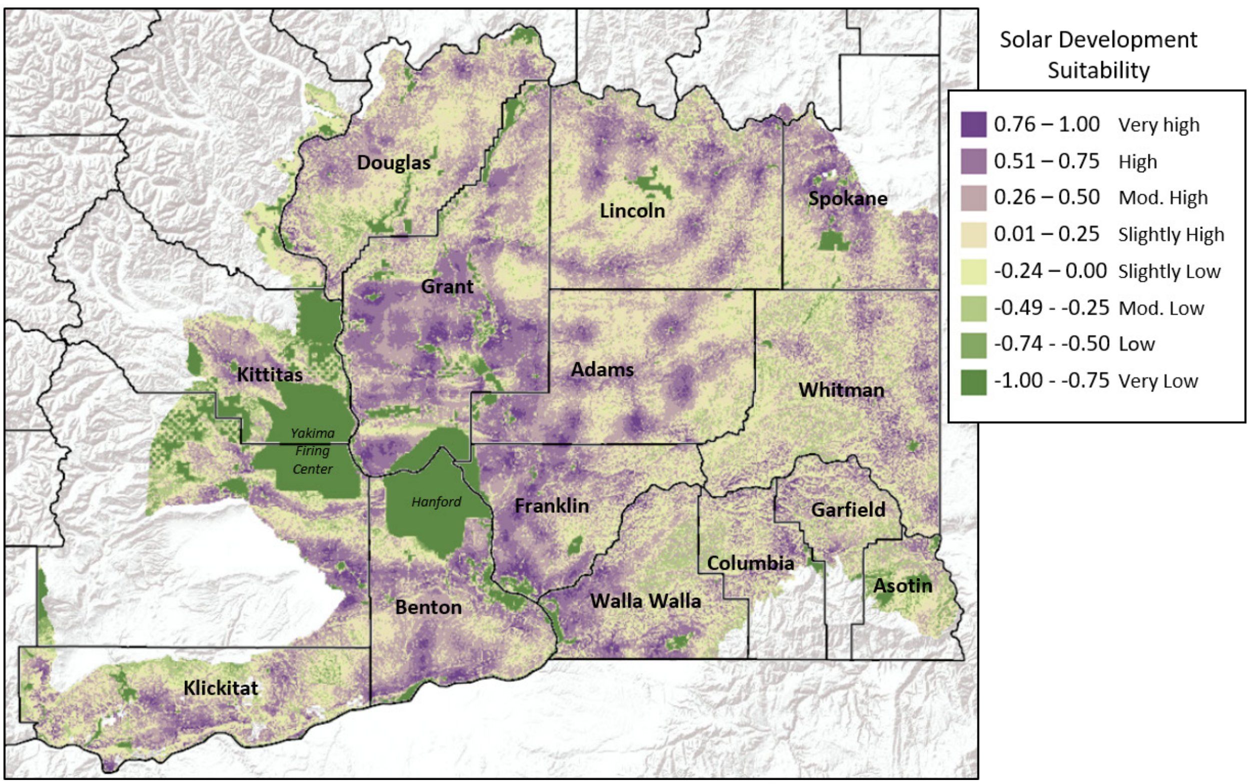


Figure 6. *Final solar development suitability map results for the Washington Columbia Plateau.*

Table 1. *Summary statistics (cell counts, acres, and percentages) for the solar development suitability model for the eight-bin score ranges, and their associated ranks.*

Solar suitability score		Solar suitability rank	Cell count	Acres	Percent of study area
-1.000000	-0.750000	Very Low	20,963	1,295,016	9.09%
-0.749999	-0.500000	Low	4,365	269,653	1.89%
-0.499999	-0.250000	Moderately Low	13,560	837,686	5.88%
-0.249999	0.000000	Slightly Low	30,375	1,876,454	13.18%
0.000001	0.250000	Slightly High	51,570	3,185,801	22.37%
0.250000	0.500000	Moderately High	62,135	3,838,467	26.95%
0.500001	0.750000	High	40,640	2,510,587	17.63%
0.750001	1.000000	Very High	6,934	428,357	3.01%
		Totals	230,542	14,242,020	100.00%

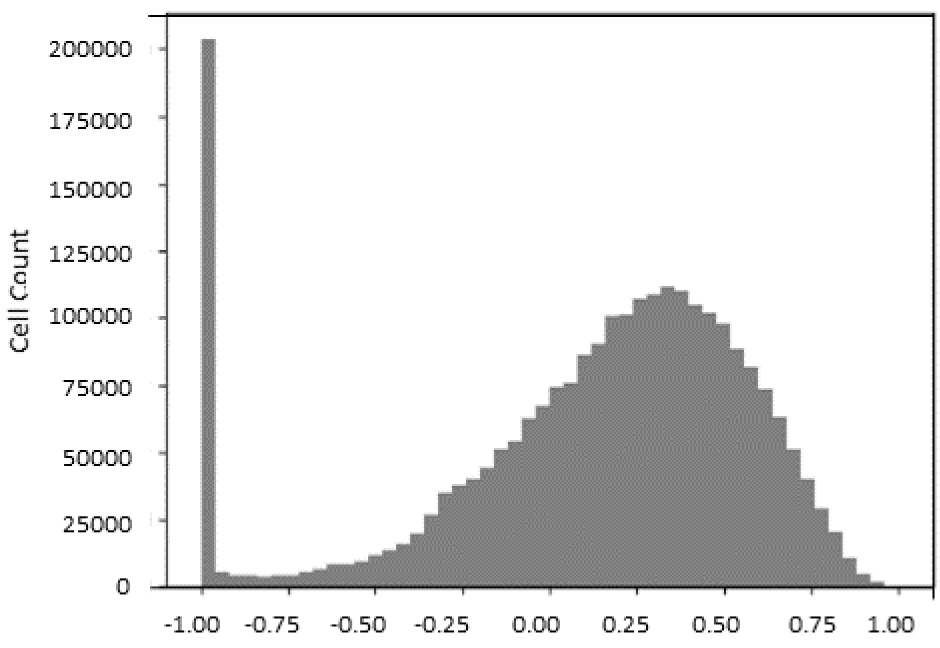


Figure 7. *Histogram of cell counts for each EEMS model value for solar development suitability.*

Solar Industry Mapping Group Participants

- Aaron Gunderson – Franklin County Planning & Building Department
- Aaron Peterson – Washington State Department of Commerce
- Daphne Lughes – Scout Clean Energy
- Donette Miranda – Clearway Energy Group
- Emily Griffith – Renewable Northwest
- Kate Brouns – Renewable Northwest
- Madeline Symm – Cypress Creek Renewables
- Matthew Pagan - Enel
- Nora Hawkins – Washington State Department of Commerce
- Tanner Gillespie – OneEnergy Renewables
- Troy Rahmig – Tetra Tech

Farmland Mapping Group

The goal of the farmland mapping group was to produce a map that illustrates the relative value of irrigated and dryland farming lands based on available spatial data.

Farmland Value Model Structure and Description

The farmland value model is composed of three main branches: (A) High Drylands Quality, (B) High Irrigated Farmland Quality, and (C) Exclusions (**Figure 8**). There are a total of 15 different input datasets from nine different sources (see sidebar). In most instances a single dataset was included as a single model input. However, sometimes the relationships between data sources and model inputs were less straightforward. In some cases, multiple datasets were merged to create a single input (e.g., Buffered Engineered Water Lines and Wells).

A. **High Drylands Quality** was created from two inputs – Good Growing Conditions and Existing Dryland Quality. Good Growing Conditions is composed of High Annual Precipitation (in mm) and Good Dryland Soil Capacity which is based on High Water Storage (cm), High Crop Productivity Index, and High Soil Depth, which is based on the Average Depth to Resistant Layer (cm). To create the Good Dryland Soil Capacity node, High Crop Productivity Index was weighted twice as much as the other two factors. This intermediate map was combined with the High Annual Precipitation node with an equally WEIGHTED UNION operator. Existing Dryland Quality was based on the WEIGHTED SUM of Conservation Reserve Lands (CRP) and existing Dryland Agriculture, which was weighted twice as much as the CRP lands. High Drylands Quality is created with the UNION of Good Growing Conditions and Existing Dryland Quality sub-branches.

B. **High Irrigated Farmlands Quality** was created from three inputs – Irrigated Water Supply, Good Irrigated Farm Soils and Existing Irrigated Agriculture. Irrigated Water Supply is made up of Buffered Engineered Water Lines & Water Wells, distribution of Irrigation Districts, and Odessa enhancement area, which is embedded in the Irrigation Districts input. Good Irrigated Farm Soils was composed of Good Irrigation Capability node (using a WEIGHTED SUM operator), High Water Storage (cm), and High Soil Organic Matter. When combined, Good Irrigation Capability was weighted twice as much as the other two factors. Existing Irrigated Agriculture is derived from the Washington Crops data. High Irrigated Farmland Quality was created by combining Irrigated Water Supply, Good Irrigated Farm Soils, and Existing Irrigated Agriculture using a WEIGHTED UNION operator.

High Farmland Quality is represented by the combination of the High Drylands Quality node and the High Irrigated Farmland node with the higher value of the two inputs carried forward using an OR operator.

C. **Exclusions** are composed of three components: (1) City Limits, (2) Surface Water Density (NHD Water Density), and (3) Protected Areas. Protected Areas included as

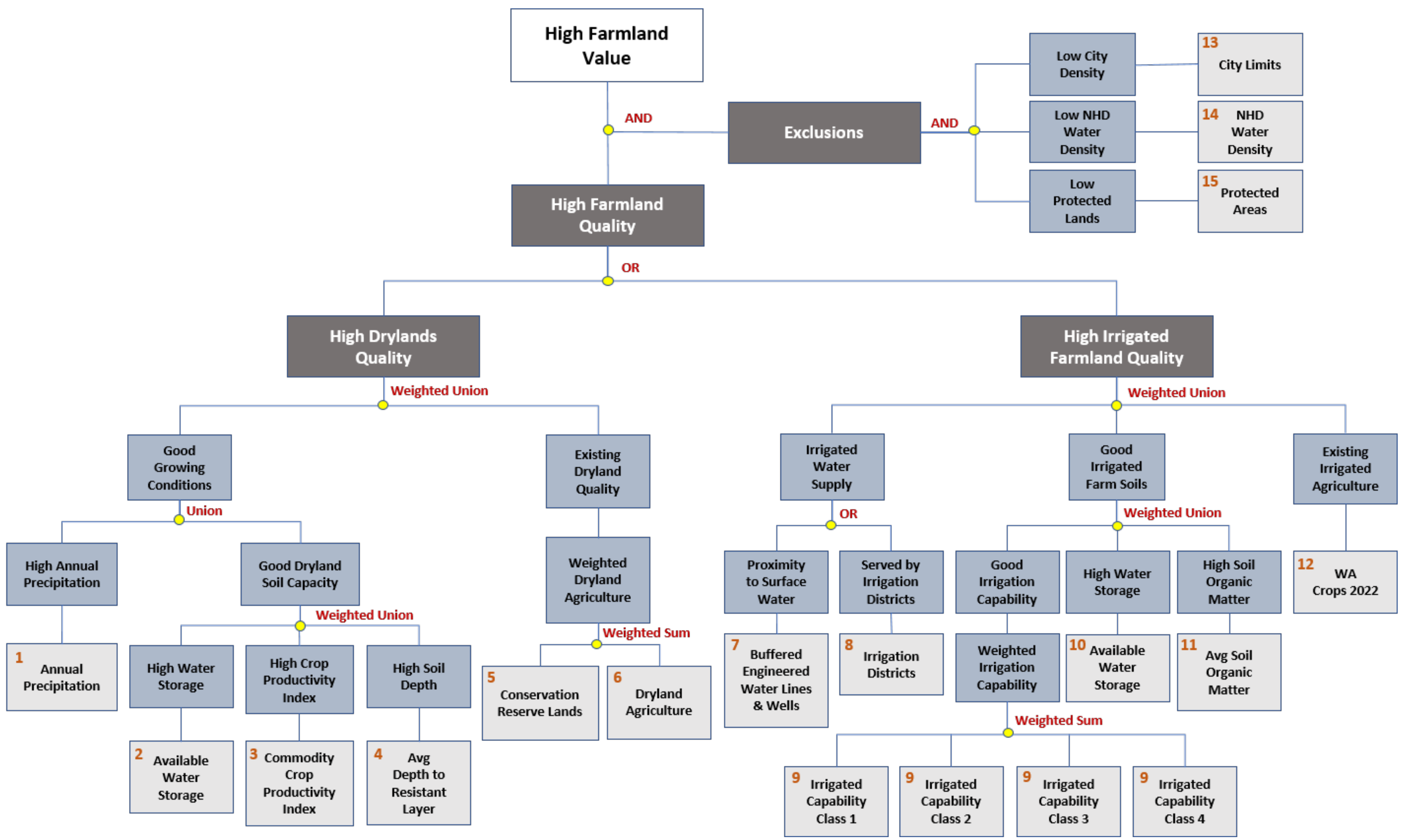


Figure 8. *EEMS tree-based model diagram for the Farmland Value Model showing individual model inputs (gray boxes), intermediate map after fuzzy command (blue boxes), high-level nodes (dark gray boxes with white text), and apex map (white box at the top of the diagram). Logic operators are indicated in dark red text (see Appendix B for descriptions). Orange numbers in the gray boxes correspond to the data sources in **Table C-2** in **Appendix C**.*

Farmland Value Model Inputs

USDA Natural Resources Conservation Service
- Available Water Storage
- National Commodity Crop Productivity Index
- Depth to Soil Restrictive Layer
- Irrigated Capability Class

U.S. Geological Survey
- National Land Cover (2019)
- National Hydrography Dataset

Washington State Department of Ecology
- Groundwater Wells

Washington State Department of Agriculture
- Irrigated Crops 2022
- Dryland Crops 2022
- Conservation Reserve Program Lands 2022

Washington State Department of Labor and Industries
- City Limits

Open Land Map
- Soil Organic Carbon

Oregon State University
- PRISM Precipitation 1991-2020

Roza Irrigation District + Expert Input
- Irrigation Districts

Conservation Biology Institute
- Protected Areas Database

exclusions were all GAP Status 1&2 lands (Scott et al. 1993)[47] plus the Hanford Nuclear Reservation and Yakima Firing Center. In order to indicate these areas as the lowest ranchland value, these combined areas were given a value of -1 and then added to the High Farmland Quality node using an AND operator at the top of the logic-tree.

Farmland Value Model Inputs

All data inputs included in the model are listed in **Table C-2**, and include model reference numbers, dataset titles, source(s), and Gateway links. Links to all model data sources can be accessed in the Gateway from a single link (***https://wsuenergy.databasin.org/galleries/b7e3facd2f214c0eaeaa3983969eef3e/#expand=352377***).

Farmland Value Model Results

The Final Farmland Value map for the Washington Columbia Plateau is presented in **Figure 9**, with the corresponding summary statistics for the eight-class numeric bins displayed on the map provided in **Table 2**. Highest value areas are shown as red and least value areas are shown in blue. The highest value areas are the irrigated portion of the landscape. Dryland agriculture is most valuable in the eastern-most portion of the region (dark orange) coinciding with the Palouse. Summary results can also be viewed in a more continuous fashion (**Figure 10**). The highest cell count along the continuum was for -1.00, which was largely due to existing protected areas, Hanford, and the Yakima Firing Center. Other locations contributing to the totally false farmland value are existing urban development and surface water. A diagram showing various map panels can be viewed in **Figure D-2**). All map panels in the Farmland Value Model can be viewed and fully explored in the Gateway by opening the file called Farmland Value EEMS Model, Washington Columbia Plateau – Least-Conflict Solar Project and clicking the EEMS Explorer icon (***https://wsuenergy.databasin.org/datasets/9a1e28e71cd4426392d549d8cd24bca1/***).

47 GAP status is the measure of management intent to permanently protect biodiversity. See Scott, J.M., F. Davis, B. Csuti, et al. 1993. *Gap Analysis: A Geographic Information Approach to Protection of Biological Diversity. Wildlife Monographs, No. 123. 41pp. https://www.jstor.org/stable/pdf/3830788.pdf*

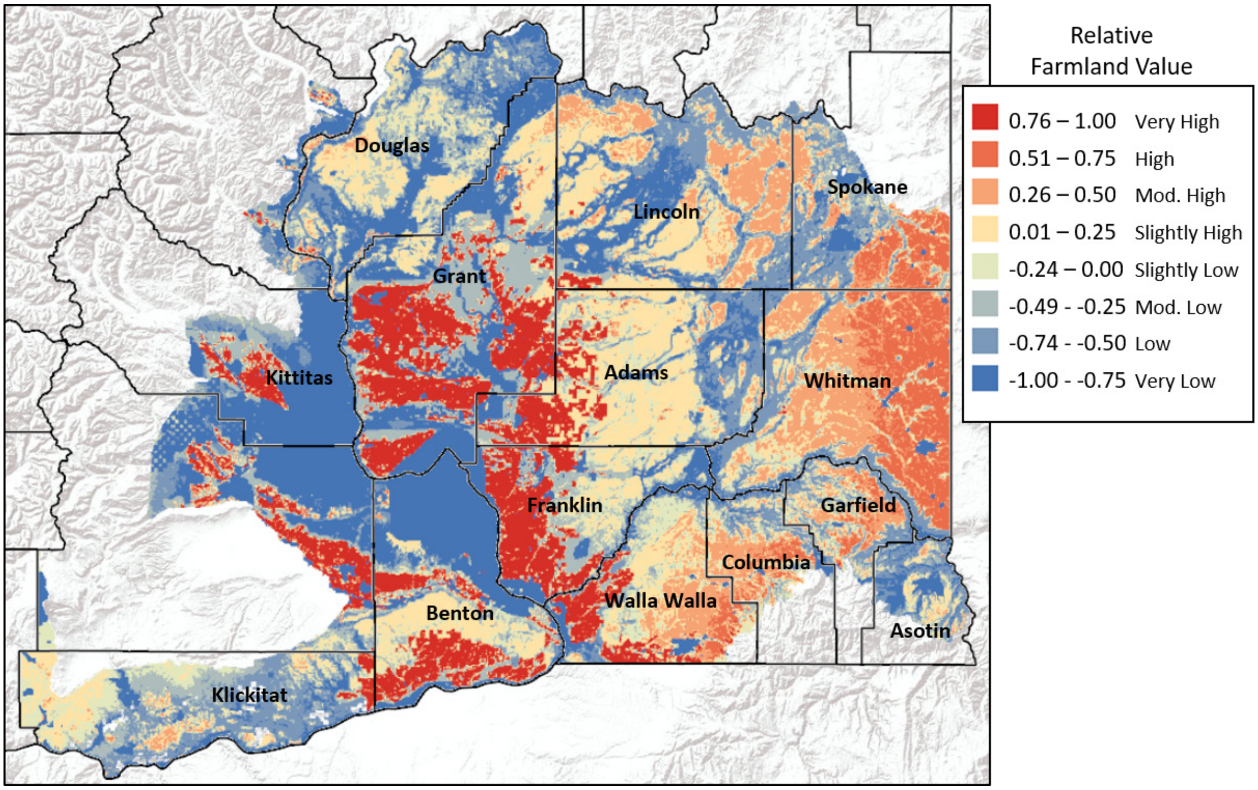


Figure 9. *Final farmland value map results for the Washington Columbia Plateau.*

Table 2. *Summary statistics (cell counts, acres, and percentages) for the farmland value model for the eight-bin score ranges and their associated ranks.*

Farmland value score		Farmland value rank	Cell count	Acres	Percent of study area
-1.000000	-0.750000	Very Low	52,829	3,263,578	22.92%
-0.749999	-0.500000	Low	30,039	1,855,697	13.03%
-0.499999	-0.250000	Moderately Low	29,552	1,825,612	12.82%
-0.249999	0.000000	Slightly Low	22,740	1,404,792	9.86%
0.000001	0.250000	Slightly High	34,967	2,160,130	15.17%
0.250000	0.500000	Moderately High	22,743	1,404,977	9.87%
0.500001	0.750000	High	12,997	802,906	5.64%
0.750001	1.000000	Very High	24,675	1,524,329	10.70%
		Totals	230,542	14,242,020	100.00%

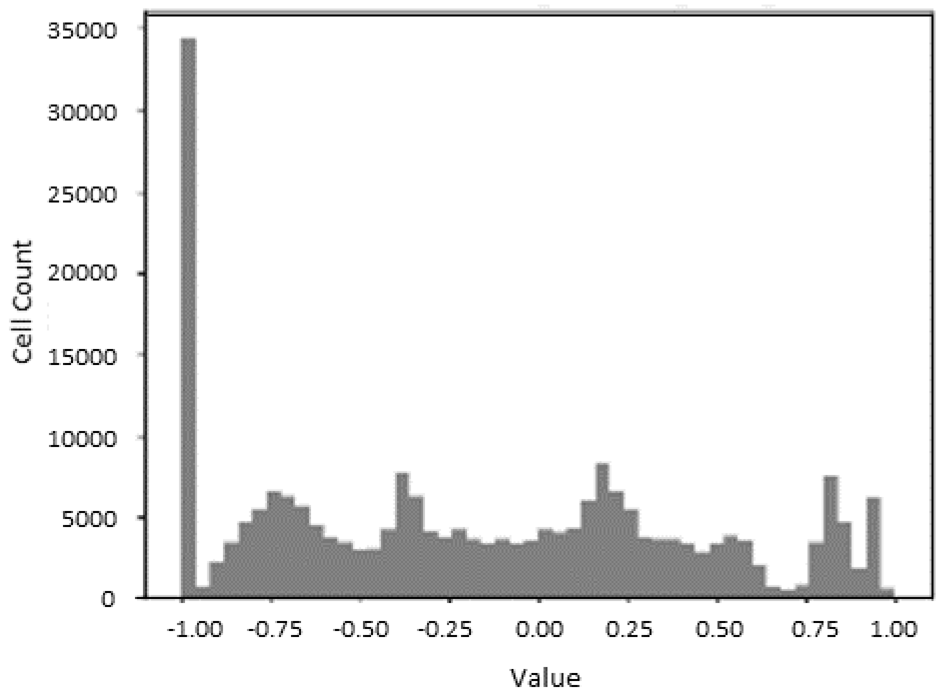


Figure 10. *Histogram of cell counts for each EEMS model value for farmland value.*

Farmland Mapping Team Participants

- Aaron Gunderson – Franklin County Planning & Building Department
- Aaron Peterson – Washington State Department of Commerce
- Chantel Welch – American Farmland Trust
- Dani Madrone – American Farmland Trust
- Gregory Wendt – Benton County Planning
- Jay Kehne – Conservation Northwest
- Jesse Ingels – Washington State Land for Sale, LLC
- Joseph Dyer – U.S. Department of Agriculture, Natural Resources Conservation Service
- Josh Monaghan – Washington Farmland Trust
- Keith Watson – Conservation Northwest
- Knowledge Murphy – American Farmland Trust
- Mark Nielson – Franklin/Benton Conservation District
- Michael Ritter – Washington Department of Fish & Wildlife
- Paul D'Agnolo – Washington State Conservation Commission
- Perry Beale – Washington State Department of Agriculture
- Scott Kane – Rancher, Landowner
- Steven B. Campbell – U.S. Department of Agriculture, Natural Resources Conservation Service

Ranchland Mapping Group

The goal of the ranchland mapping group was to produce a map that illustrates the relative value of ranchlands based on available spatial data.

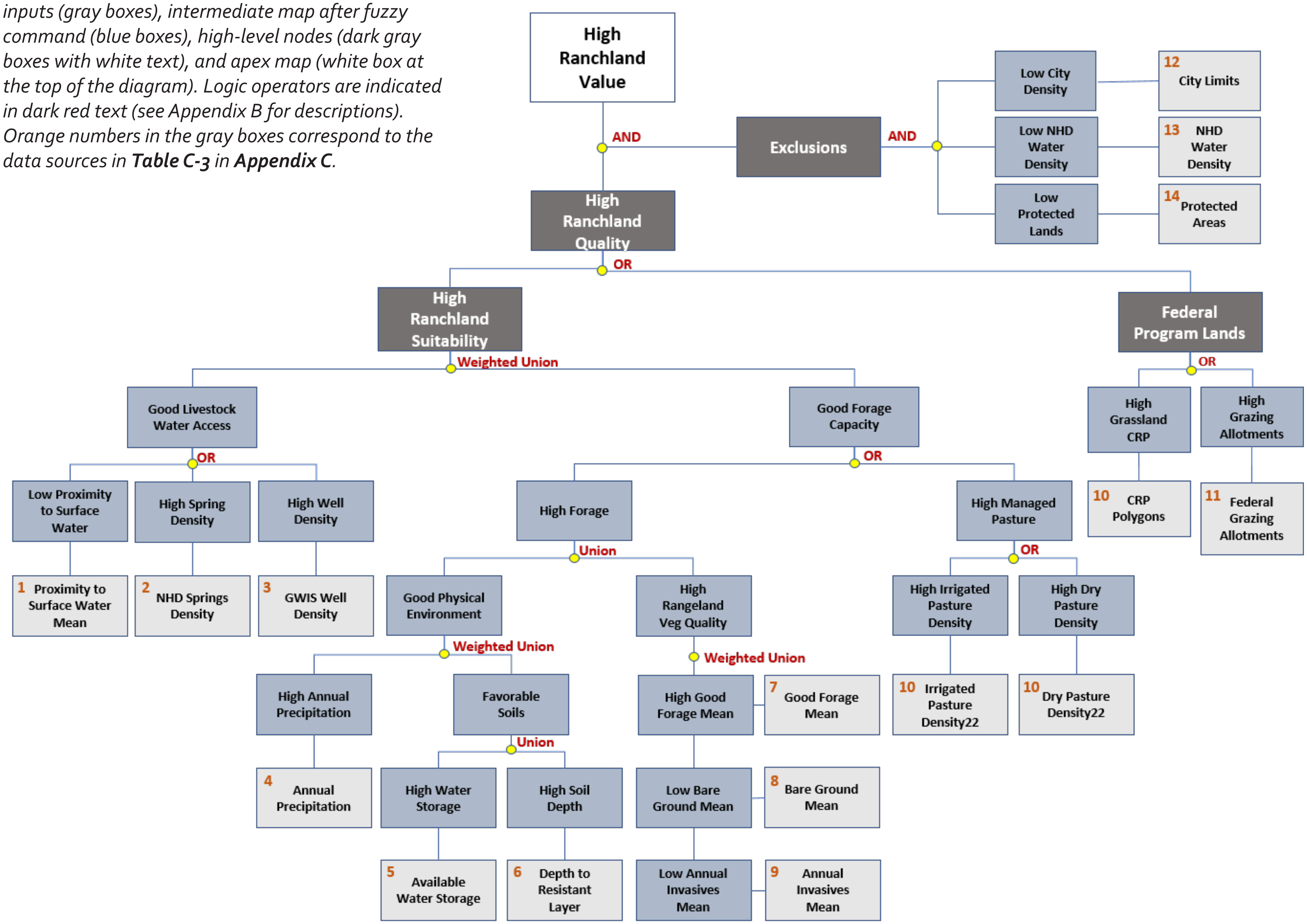
Ranchland Value Model Structure and Description

The model is composed of three main branches: High Ranchland Suitability, Federal Program Lands, and Exclusions (**Figure 11**). A total of 14 different input datasets were included from nine different sources. In most instances a single dataset was included as a single model input. However, in some instances, the relationship between data sources and model inputs were less straightforward. For example, subsets of a single dataset were split to create separate model inputs (e.g., Washington Agricultural Crop dataset).

A. **High Ranchland Suitability** was created from two inputs – Good Livestock Water Access and Good Forage Capacity. Livestock Water Access is comprised of three inputs: Low Proximity to Surface Water, availability of springs (High Spring Density), and availability to wells (High Well Density). Perennial surface water based on the National Hydrologic Database (NHD) was buffered by 1/4 mile (1,320 feet). This entire area was assigned the same true numeric value (+1) and intersected with the 500m analytical units in the model. NHD Springs and Generalized Well Information System (GWIS) Water Wells were treated in the same way. These three inputs were combined with an OR operator resulting in the highest value of the three inputs included in the Good Livestock Water Access node.

   Good Forage Capacity was made up of two sub-branches: High Forage and High Managed Pasture. High Forage is created by the union of two other sub-branches: Good Physical Environment and High Rangeland Vegetation Quality. Good Physical Environment is comprised of inputs on Annual Precipitation and two soils inputs: High Water Storage (cm) and High Soil Depth based on the Depth to Resistant Layer (cm). Locations that are more favorable to ranching receive more moisture from rainfall and snow, with soils that are deeper and therefore capable of retaining this moisture for longer periods of time. This in turn promotes better forage quantity. The High Rangeland Vegetation Quality concentrates on the natural and semi-natural portions of the landscape and are derived from three components: Good Forage (or High Perennial Grasses), Low Bare Ground, and Low Annual Invasives. This node is dominated by the High Perennial Grass (or Good Forage) input moderated by the other two negative influences. The final sub-branch that contributes to the Good Forage Capacity node is the inclusion of Managed Pasture, which is made up of two sub-branches, both of which are mapped by the Washington State Department of Agriculture (2022). Irrigated Pasture is given a slightly higher value compared to the Dry Pasture (controlled by different thresholds) due to the difference in forage quality. The High Ranchland Suitability node was created by combining Good Livestock Water Access and Good Forage Capacity using a WEIGHTED UNION operator favoring forage over water availability.

Figure 11. *EEMS tree-based model diagram for the Ranchland Value Model showing individual model inputs (gray boxes), intermediate map after fuzzy command (blue boxes), high-level nodes (dark gray boxes with white text), and apex map (white box at the top of the diagram). Logic operators are indicated in dark red text (see Appendix B for descriptions). Orange numbers in the gray boxes correspond to the data sources in* ***Table C-3*** *in* ***Appendix C****.*



Ranchland Value Model Inputs

USDA Natural Resources Conservation Service
- Available Water Storage
- Depth to Soil Restrictive Layer

U.S. Geological Survey
- Seeps and Springs
- National Hydrography Dataset

Washington State Department of Ecology
- Groundwater Wells

Washington State Department of Agriculture
- Irrigated Crops 2022
- Dryland Crops 2022
- Conservation Reserve Program Lands 2022

Bureau of Land Management
- Grazing Allotments

Washington State Department of Labor and Industries
- City Limits

Multi-Agency
- Perennial Grasses and Forbes
- Bare Ground
- Annual Invasives

Oregon State University
- PRISM Precipitation 1991-2020

Conservation Biology Institute
- Protected Areas Database

B. The Federal Program Lands branch was created by combining the mapped federal land grazing allotments and the USDA Conservation Reserve Program (CRP) enrollments with the CRP lands slightly demoted since they are not routinely grazed in most years.

High Ranchland Quality is represented by the combination of the High Ranchland Suitability node and the Federal Program Lands node with the higher value of the two inputs carried forward.

C. **Exclusions** was composed of three components: (1) City Limits, (2) NHD Water Density, and (3) Protected Areas. Protected Areas included as exclusions were all GAP Status 1&2[48] lands plus the Hanford Nuclear Reservation and Yakima Firing Center. In order to indicate these areas as the lowest ranchland value, these combined areas were given a value of -1 and then added to the High Ranchland Quality node using an AND operator at the top of the logic-tree.

Ranchland Value Model Inputs

All data inputs included in the model are listed in **Table C-3** in **Appendix C**, which includes model reference numbers, dataset titles, source(s), and Gateway links. Links to all model data sources can be accessed in the Gateway from a single link (***https://wsuenergy.databasin.org/galleries/72ec6d6075db 4e26a9f999f4a750dfa4/#expand=35252***4).

Ranchland Value Model Results

The Final Farmland Value map for the Washington Columbia Plateau is presented in **Figure 12**, with the corresponding summary statistics for the eight-class numeric bins displayed on the map provided in **Table 3**. Highest value areas are shown as red and least value areas are shown in blue. The highest value areas are lands currently dedicated to grazing. Natural and dryland agriculture in close proximity

48 GAP status is the measure of management intent to permanently protect biodiversity. See Scott, J.M., F. Davis, B. Csuti, et al. 1993. Gap Analysis: A Geographic Information Approach to Protection of Biological Diversity. Wildlife Monographs, No. 123. 41pp. *https://www.jstor.org/stable/pdf/3830788.pdf*

to water showed higher value than neighboring lands. Summary results can also be viewed in a more continuous fashion (**Figure 13**). The highest cell count along the continuum was for -1.00, which was largely due to existing protected areas, Hanford, and the Yakima Firing Center. Other locations contributing to the totally false ranchland value are existing urban development and surface water. A diagram showing various map panels can be viewed in **Figure D-3**. All map panels in the Ranchland Value model can be viewed and fully explored in the Gateway by opening the file called Ranchland Value EEMS Model, Washington Columbia Plateau – Least-Conflict Solar Project and clicking the EEMS Explorer icon (***https://wsuenergy.databasin.org/datasets/573d3b09d3844f33b9c52f0aa4e6036f/***).

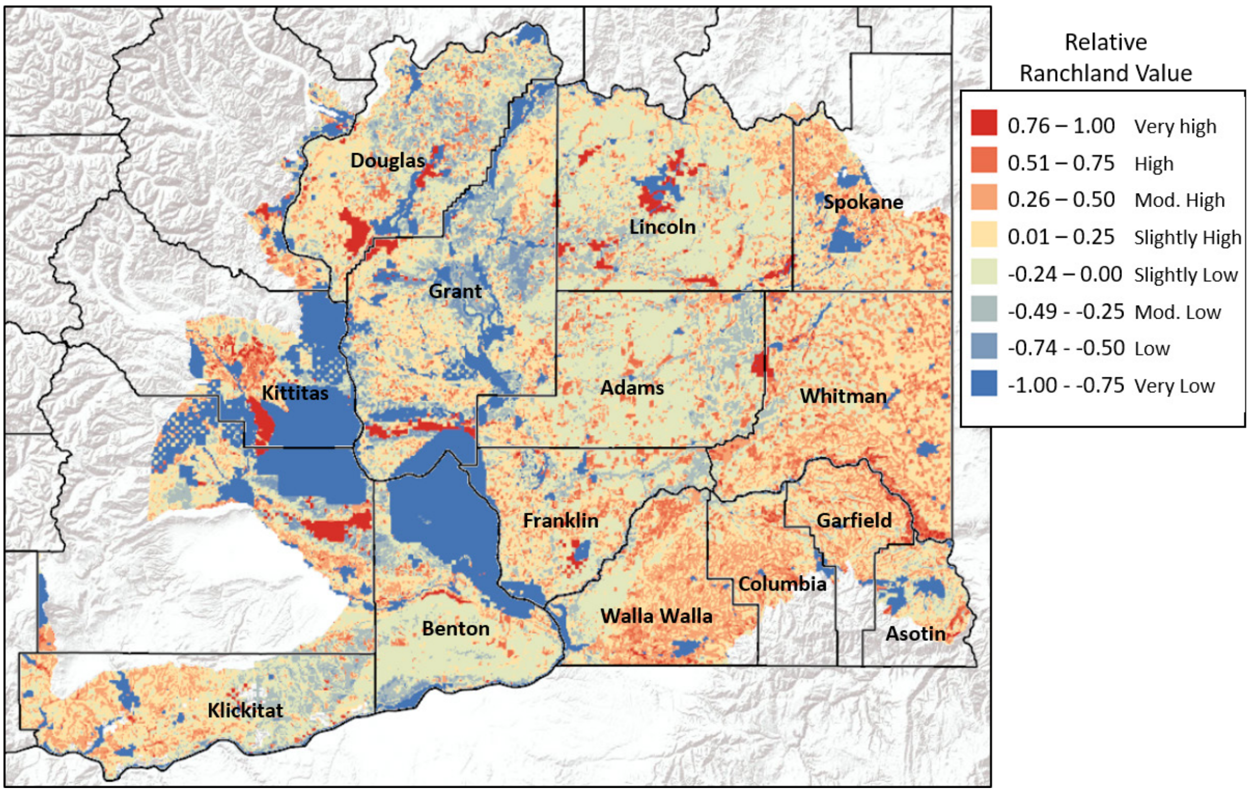


Figure 12. *Final ranchland value map results for the Washington Columbia Plateau.*

Table 3. *Summary statistics (cell counts, acres, and percentages) for the ranchland value model for the eight-bin score ranges and their associated ranks.*

Ranchland value score		Ranchland value rank	Cell count	Acres	Percent
-1.000000	-0.750000	Very Low	34,407	2,125,535	14.92%
-0.749999	-0.500000	Low	3,395	209,730	1.47%
-0.499999	-0.250000	Moderately Low	21,017	1,298,351	9.12%
-0.249999	0.000000	Slightly Low	65,388	4,039,425	28.36%
0.000001	0.250000	Slightly High	54,300	3,354,450	23.55%
0.250000	0.500000	Moderately High	34,757	2,147,157	15.08%
0.500001	0.750000	High	11,309	698,628	4.91%
0.750001	1.000000	Very High	5,969	368,742	2.59%
		Totals	230,542	14,242,020	100.00%

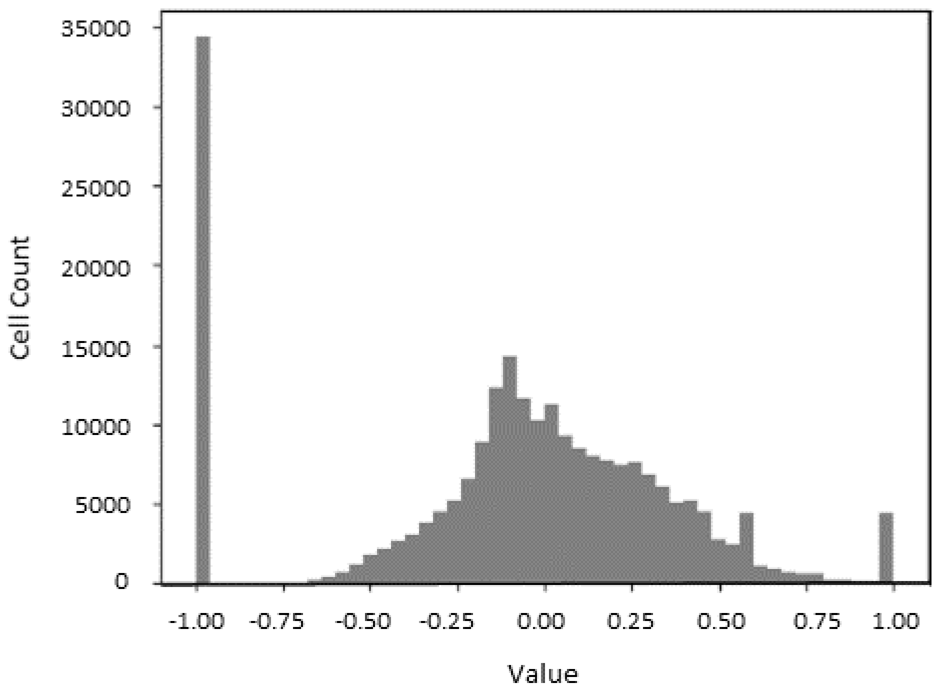


Figure 13. *Histogram of cell counts for each EEMS model value for ranchland value .*

Ranchland Mapping Team Participants

- Aaron Gunderson – Franklin County Planning & Building Department
- Aaron Peterson – Washington State Department of Commerce
- Chantel Welch – American Farmland Trust
- Dani Madrone – American Farmland Trust
- Gregory Wendt – Benton County Planning
- Jay Kehne – Conservation Northwest
- Jesse Ingels – Washington State Land for Sale, LLC
- Joshua Monaghan – Washington Farmland Trust
- Keith Watson – Conservation Northwest
- Levi Keesecker – Washington State Conservation Commission
- Michael Ritter – Washington Department of Fish & Wildlife
- Mickey Fleming – Chelan-Douglas Land Trust
- Paul D'Agnolo – Washington State Conservation Commission
- Perry Beale – Washington State Department of Agriculture
- Scott Kane – Rancher, Landowner

Environmental Conservation Mapping Group

The goal of the environmental conservation mapping group was to produce a map that illustrates the relative value of environmental conservation lands based on available spatial data.

Environmental Conservation Value Model Structure and Description

The High Conservation Value model was the most complex model developed among the mapping groups (**Figures 14**, **15**, and **16**). There are seven high-level map elements (dark gray panels). The main branches include: (A) Landcover Adjusted Listed Species Habitat, (B) High Protected Areas, (C) High Conservation Value Composite, (D) Connectivity Value, and (E) Combined Species Communities Value, which is composed of the two largest branches in the model (Natural Communities Value and Focal Species Value). A total of 61 separate inputs from nine different sources were included in the model.

High Conservation Value (the apex of the model) was created by combining three high-level inputs – Landcover Adjusted Listed Species Habitat, High Protected Areas, and High Conservation Value Composite using the OR operator.

A. **Landcover Adjusted Listed Species Habitat** was created by first aggregating all listed species habitat into a single (1,0) map layer modified by land use (see Figure 16). A Landcover Weighted Sum map was created by using the SUM command weighting different landcover classes: natural lands (1.00), CRP lands (.85), dryland ag (.75), irrigated farmland (.50), and developed (-1.00). This map was combined with the Listed Species map using the MULTIPLY command. The result provided level of landscape quality from the standpoint of listed species.

B. **High Protected Areas** was defined as public lands with GAP Status 1&2 lands plus all private protected lands and conservation easements.

C. **High Conservation Value Composite** was formed using a WEIGHTED UNION operator between Connectivity Value and Combined Species Communities Value, which were weighted equally, plus Other Conservation Priorities Value, which was excluded from the integration due to the spatially coarse nature of the data. Other Conservation Priorities Value was included in the model solely to provide additional validation of areas identified as important by other assessments, specifically The Nature Conservancy (TNC) Conservation Portfolio Areas and Audubon Important Bird Areas.

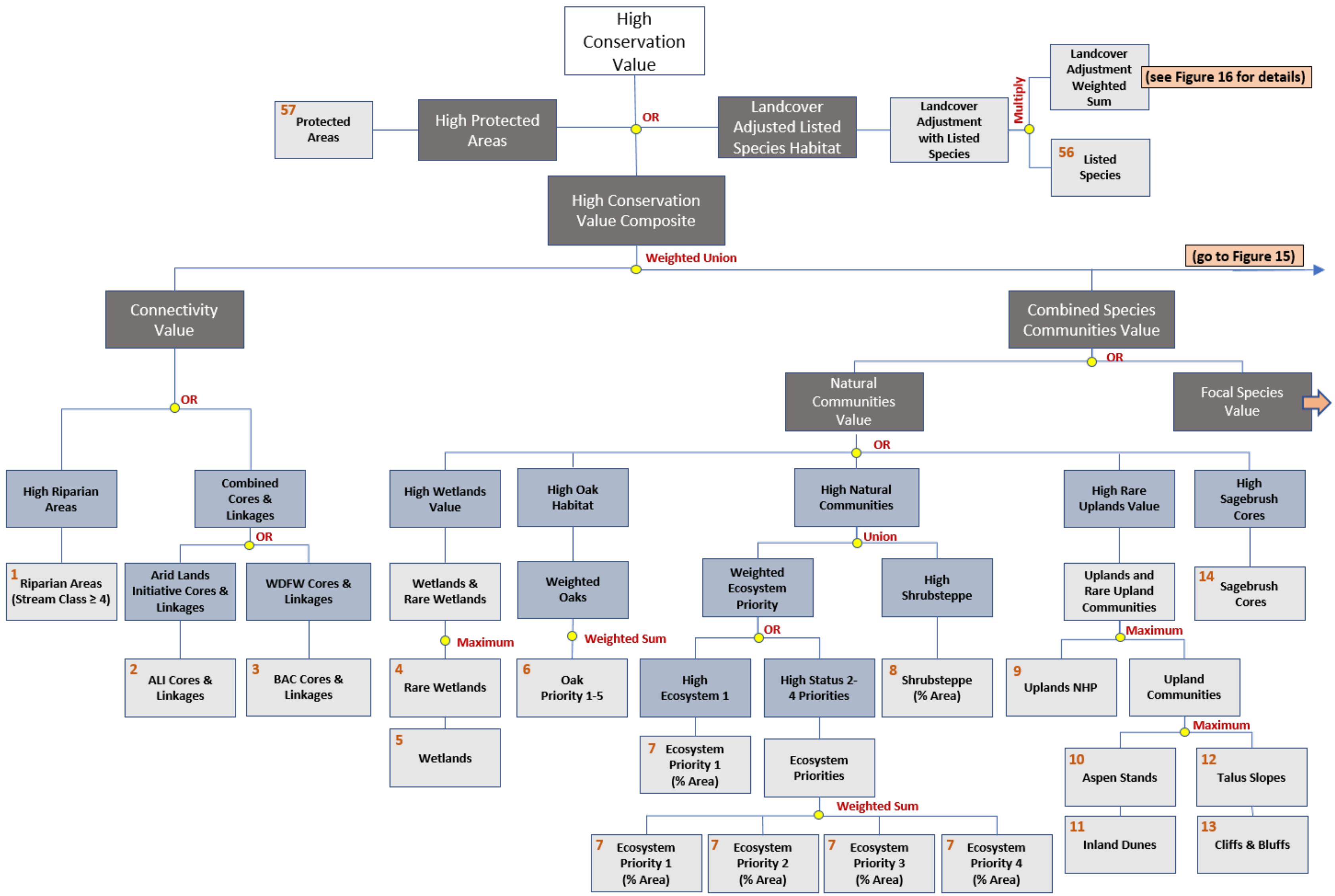


Figure 14. *EEMS tree-based model diagram for the Conservation Value Model showing individual model inputs (gray boxes), intermediate map after fuzzy command (blue boxes), high-level nodes (dark gray boxes with white text), and apex map (white box at the top of the diagram). Logic operators are indicated in dark red text (see Appendix B for descriptions). Orange numbers in the gray boxes correspond to the data sources in* ***Table C-4*** *in* ***Appendix C****.*

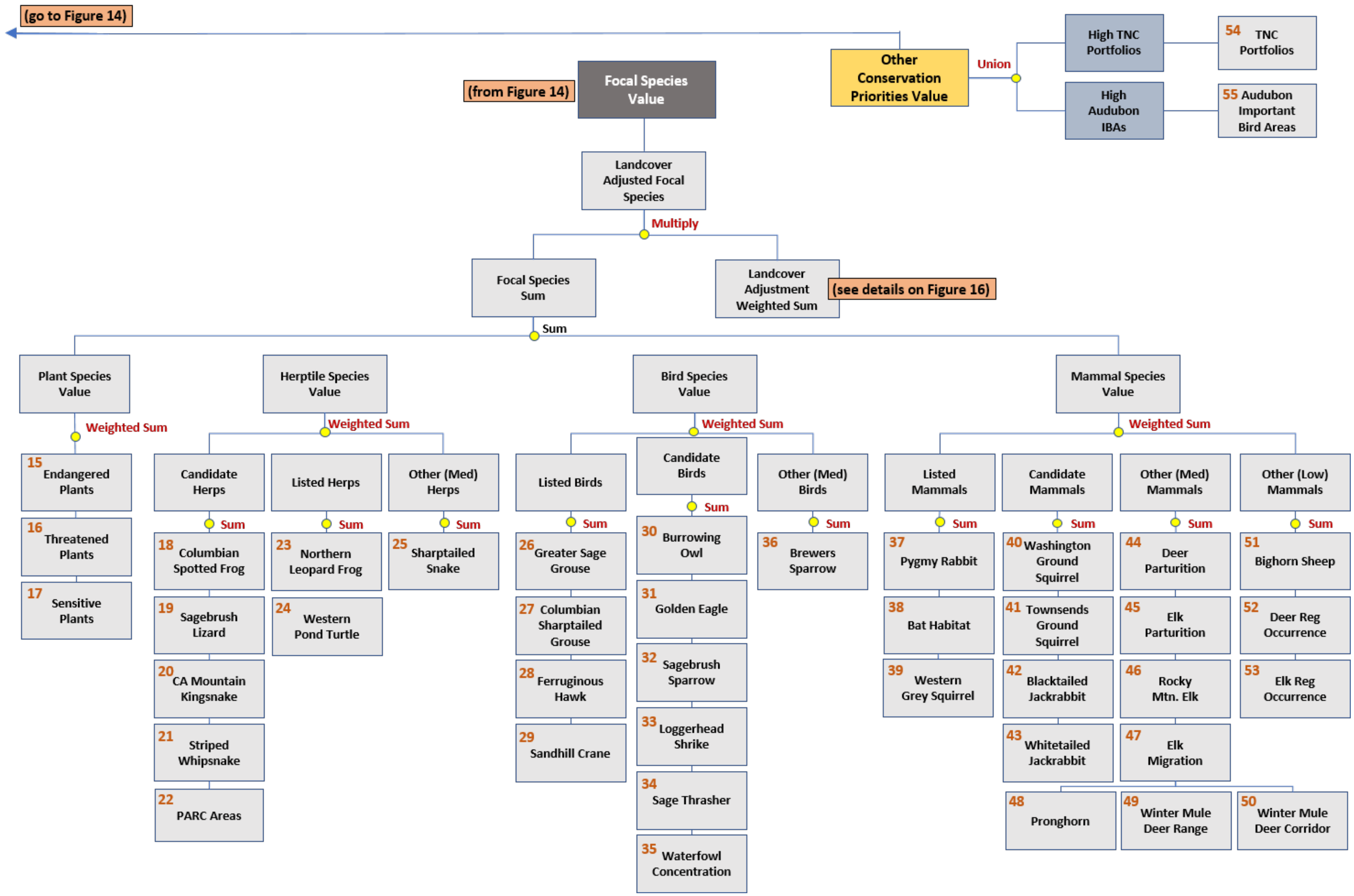


Figure 15. *EEMS tree-based model diagram for the Conservation Value Model showing individual model inputs (gray boxes), intermediate map after fuzzy command (blue boxes), high-level nodes (dark gray boxes with white text), and apex map (white box at the top of the diagram). The yellow box depicts a node that denotes support without impacting final map results. Logic operators are indicated in dark red text (see Appendix B for descriptions). Orange numbers in the gray boxes correspond to the data sources in* ***Table C-4*** *in* ***Appendix C****.*

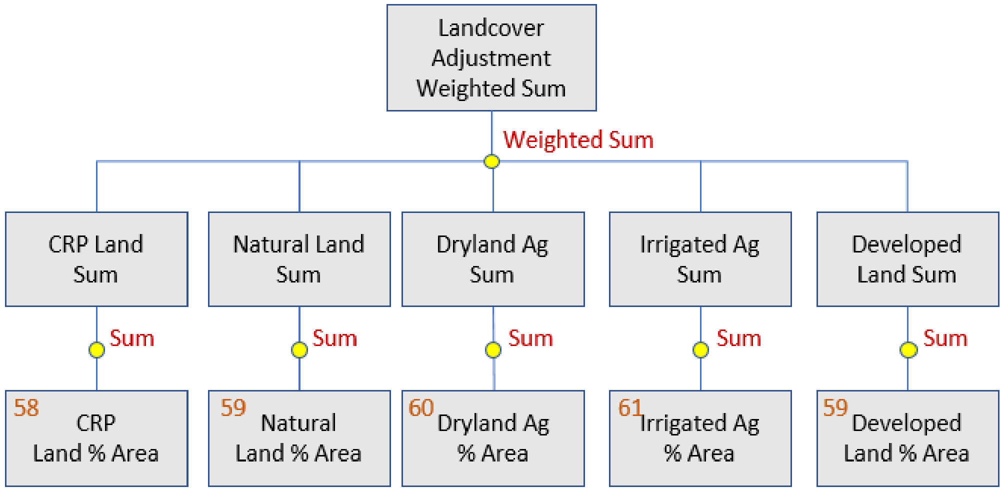


Figure 16*. EEMS tree-based model diagram for the environmental conservation value model.*

D. **Connectivity Value** was created from three data sources: Riparian Areas, Arid Land Initiative Cores & Linkages, and WDFW Cores & Linkages using the OR operator. Riparian Areas were derived from the U.S. Geological Survey NHD streams data. All stream orders ≥ 4 (Strahler 1957)[49] were identified as riparian habitat for this model. All three inputs were combined resulting in a 1/-1 map layer.

E. **Combined Species Communities Value** was created using the OR operator between **Natural Communities Value** and **Focal Species Value**.

Natural Communities Value was created by combining five high-level intermediate maps – High Wetland Value, High Oak Habitat, High Natural Communities, High Rare Highlands Value, and High Sagebrush Cores using an OR logic operator.

The **High Wetland Value** node was created using two different wetland inputs. Rare Wetlands were given the highest value (2.0) and all other wetlands assigned a value of (1.75). A MAXIMUM operator was used to superimpose the highest value on the map before converting to fuzzy with a True threshold of 2.0.

The **High Oak Habitat** node was based on a single assessment that ranked oak woodlands from the highest (priority 1) to lowest (priority 5). This section of the model was set up to differentiate the different priorities using a WEIGHTED SUM operator, but after review all oak habitats were given the same ranking. The original rankings based on priority were left so that this information could be reviewed if needed.

49 Strahler, A.H. 1957. Quantitative analysis of watershed geomorphology, Transactions of the American Geophysical Union, 38 (6): 913-920. *https://www.scrip.org/(S(351jmbntvnsjt1aadkposje))/reference/referencepapers.aspx?referenceit=1451623*

Environmental Conservation Value Model Inputs

Washington Department of Fish & Wildlife
(Species Habitats)

Mammals
• Bats
• Pygmy Rabbit
• Western Grey Squirrel
• Townsend's Ground Squirrel
• Washington Ground Squirrel
• Black-tailed Jackrabbit
• White-tailed Jackrabbit
• Elk
• Rocky Mountain Elk
• Mule Deer
• Pronghorn Antelope
• Bighorn Sheep

Birds
• Columbian Sharptailed Grouse
• Ferruginous Hawk
• Greater Sage Grouse
• Sandhill Crane
• Burrowing Owl
• Golden Eagle
• Sagebrush Sparrow
• Loggerhead Shrike
• Sage Thrasher
• Waterfowl Concentration Areas
• Brewer's Sparrow

Reptiles and Amphibians
• Northern Leopard Frog
• Western Pond Turtle
• Columbia Spotted Frog
• Sagebrush Lizard
• California Mountain Kingsnake
• Striped Whipsnake
• Sharp-tailed Snake
• Priority Amphibian and Reptile Conservation Areas

The **High Natural Communities** node was more complex in model structure, but only relied on two inputs: Weighted Ecosystem Priority (WDFW Rare Ecosystems of Concern) and High Shrubsteppe. For the Rare Ecosystems file, we merged the numerous rarity status codes into four basic categories: Status 1 = S1 and S1S2, Status 2 = S2 and S2S3, Status 3 = S3, S3S4, and S3S5, and Status 4 = S4, S4?, and S4S5. The resolution for both files was considerably smaller (30m) than our analytical grid size (500m), so the percent area for each category for every cell was calculated. The Status 1 node was separated from the other three inputs and combined later in the model in order to allow for this most rare group to override a composite score of all rare types. Another node was composed using a WEIGHTED SUM operator (Status 1-Status 4), with weights of 25, 10, 5, and 2, respectively, before conversion to fuzzy with True = 1000 and False = 0. The Status 1 cells that were >50% were assigned a true value of +1 and then combined with the other combined status results using an OR operator, creating the Weighted Ecosystem Priority node. This was then combined with the High Shrubsteppe map node, which was created using a simple percent area with 100% = True (+1) and 0% = False (-1), using a UNION operator.

The **High Rare Highlands Value** node was created by combining five input files, which were combined using a MAXIMUM operator. Locations that contained any one of four mutually exclusive rare highland community types – Aspen Stands, Inland Dunes, Talus Slopes, and Cliffs & Bluffs – within the Highlands Priority Habitat and Species (PHS) input layer were given the highest value (+1) while all other areas received a value score of 0.75.

The High Sagebrush Core Areas was created from a single source and simply assigned a TRUE value of (+1).

Focal Species Value was the most complex node in the Conservation Value model, including 40 separate inputs. Data inputs were provided from two sources: Washington Department of Fish & Wildlife (WDFW) and the Washington Natural Heritage Program. Using the publicly available

Washington Department of Fish & Wildlife
(Natural Communities & Connectivity)
• Highland Communities *(Aspen Groves, Inland Dunes, Talus Slopes, and Cliffs & Bluffs)*
• Wetlands
• Shrubsteppe
• Ecosystems of Concern
• Landscape Cores and Linkages

Washington State Department of Natural Resources
(Heritage Program)
• Endangered Plants
• Threatened Plants
• Sensitive Plants
• Rare Highland Communities
• Rare Wetland Communities

U.S. Fish & Wildlife Service
• Landscape Cores and Linkages

Doherty et al. (2020)
• Sagebrush Core Habitat

Columbia Land Trust
• Priority Oak Habitat

U.S. Geological Survey
• National Land Cover (2019)
• National Hydrography Dataset
• Protected Areas Database

The Nature Conservancy
• TNC Portfolio Areas

National Audubon Society
• Important Bird Areas

dataset, plant element occurrences were sorted into three categories – Endangered (n= 26 species), Threatened (n= 74 species), and Sensitive (n= 54 species) – and then combined using a WEIGHTED SUM operator with weights of 10, 5, and 3, respectively.

For animal species, we created three sub-branches: Herptile Species Value, Bird Species Value, and Mammal Species Value. For each sub-branch, we subdivided the species into potentially four groupings: Listed Species (which included all species that are classified as either endangered, threatened, or sensitive) in the state, Candidate Species, Other (Medium), and Other (Low). Each focal species input was composed of one or more individual datasets and organized in the model by taxonomic group and status. The SUM operator was used to combine all species habitats for each particular taxon and status category in order to track which species were likely to be observed for each analytical unit cell. Each taxonomic group value node was created by combining the summed results for each status category using a WEIGHTED SUM operator assigning weighting factors of 25, 10, 5, and 1. Intermediate results for each taxonomic group were combined using a SUM operator. The Focal Species Value node was modified with a Landcover Adjustment as described in the previous description of the model.

Environmental Conservation Value Model Inputs

All data inputs included in the model are listed in **Table C-4**, which includes model reference numbers, dataset titles, source(s), and gateway links. Links to all model data sources can be accessed in the Gateway from a single link (***https://wsuenergy.databasin.org/galleries/63a30569f94a49ed 8379d8c9ff3105fa/#expand=357418***).

Environmental Conservation Value Model Results

The **Final Environmental Conservation Value** map is presented in **Figure 17**, with the corresponding summary statistics for the eight-class numeric bins displayed on the map provided in **Table 4**. Highest value areas are shown as red and least value areas are shown in blue. Summary results can also be viewed in a more continuous fashion (**Figure 18**). More than any other model, the environmental conservation value results reflect more of a binary nature; large areas of low value and large areas of high value as shown in the map and supporting table and histogram. The areas of highest value primarily correspond to locations that contain habitat for one of more listed species as well as important regional connectivity zones. Areas of low value correspond to various levels of agriculture and urban development. A diagram showing various map panels can be viewed in **Figure D-4**. All map panels in the Environmental Conservation Value Model can be viewed and fully explored in the Gateway by opening the file called Environmental Conservation Value EEMS Model, Washington Columbia Plateau – Least-Conflict Solar Project (***https://wsuenergy.databasin.org/datasets/573d3b09d3844f33b9c 52f0aa4e6036f/***) and clicking the EEMS Explorer icon.

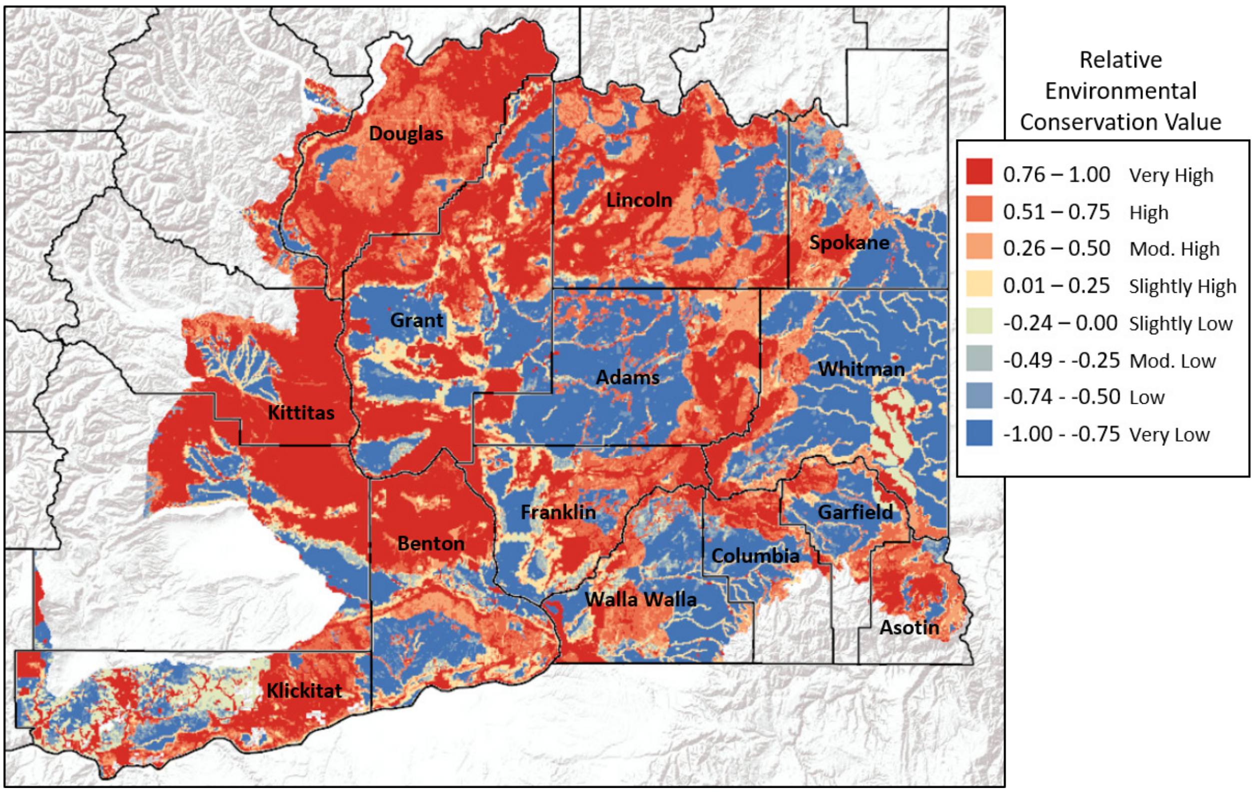


***Figure 17**. Final environmental conservation value map results for the Washington Columbia Plateau.*

Table 4. Summary statistics (cell counts, acres, and percentages) for the environmental conservation value model for the eight-bin score ranges, their associated ranks.

Environmental conservation value score		Environmental conservation value rank	Cell count	Acres	Percent
-1.000000	-0.750000	Very Low	63,233	3,906,298	27.43%
-0.749999	-0.500000	Low	7,365	454,982	3.19%
-0.499999	-0.250000	Moderately Low	4,564	281,947	1.98%
-0.249999	0.000000	Slightly Low	8,275	511,198	3.59%
0.000001	0.250000	Slightly High	15,251	942,150	6.62%
0.250000	0.500000	Moderately High	16,699	1,031,602	7.24%
0.500001	0.750000	High	34,897	2,155,806	15.14%
0.750001	1.000000	Very High	80,258	4,958,038	34.81%
		Totals	230,542	14,242,020	100.00%

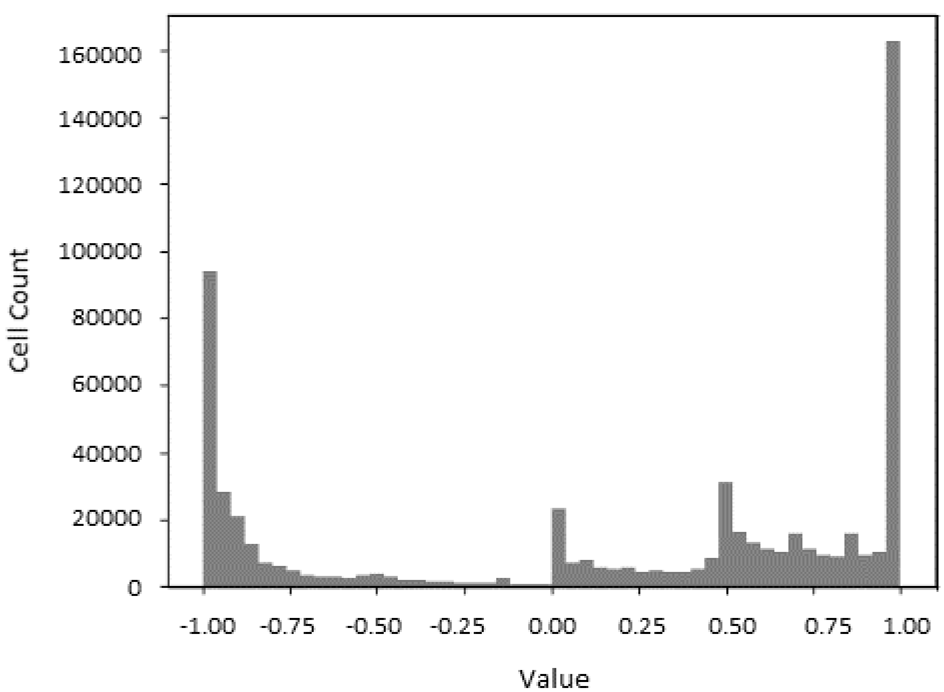


***Figure 18.** Histogram of cell counts for each EEMS model value for environmental conservation value.*

Environmental Conservation Mapping Team Participants

- Aaron Peterson – Washington State Department of Commerce
- Amy Bensted – Tetra Tech
- Aurelio Razo – Grant County Planning
- Carl Berkowitz – Lower Columbia Basin Audubon Society
- Dana C. Ward – Lower Columbia Basin Audubon Society
- Dawn M. Vyvyan – Yakama Tribe
- Debbie Berkowitz – Lower Columbia Basin Audubon Society
- Ed Lisowski – Washington Native Plant Society
- Glen Mendel – Blue Mountain Audubon Society
- Jay Kehne – Conservation Northwest
- Jesse Ingels – Washington State Land for Sale, LLC
- Joe Rocchio – Washington Department of Natural Resources
- Jon Belak – National Audubon
- Jordan Ryckman – Conservation Northwest
- Julia Michalak – Washington Department of Fish & Wildlife
- Justin Allegro – The Nature Conservancy
- Kaley Wisher – Pheasants Forever
- Keith Folkerts – Washington Department of Fish & Wildlife
- Laurie Ness – Lower Columbia Basin Audubon Society
- Marie Neumiller – Inland Northwest Wildlife Council
- Mark Nielson – Franklin Conservation District
- Mark Nuetzmann – Yakama Tribe
- Michael Ritter – Washington Department of Fish & Wildlife
- Mitch Attig – Columbia Land Trust
- Molly Jennings – Chelan-Douglas Land Trust
- Nathan Ulrich – Columbia Land Trust
- Nora Hawkins – Washington State Department of Commerce
- Norman Peck – Kittitas Audubon
- Patrick Paulson – Lower Columbia Basin Audubon Society
- Robin Priddy – Lower Columbia Basin Audubon Society
- Ryan Nelson – Franklin County Planning
- Stan Isley – Yakima Valley Audubon Society
- Tara Callaway – United States Fish & Wildlife Service
- Tina Blewett – Ducks Unlimited
- Trina Bayard – Audubon Washington

Photo by Jesse Ingels.

Composite Maps – Pulling All of the Models Together

The composite dataset that integrates all four EEMS models is one of the main digital end products of this project. It pulls high-level findings into a single dataset so the relationships between the models can be easily evaluated. The composite dataset, "EEMS Model Composite, Washington Columbia Plateau – Least-Conflict Solar Project" (***https://wsuenergy.databasin.org/datasets/5ea777fa7b 0b412a94f47e25f74e795c/***) integrates the apex (final) map of each of the final four group models. It is not an EEMS model, however, meaning that it is not possible to explore the nodes on the tree diagram as can be done with the four individual models generated during the project. The composite model is composed of the high-level findings only (score and rank) from the suitability model and the three value models. General categories were created for the suitability model results (low, moderate, and high suitability) and for each of the other resource models (low, moderate, and high conflict). Distribution of the cell count, acres, and percent of model are presented in **Table 5**.

The Solar Development Suitability Model serves as the foundation of the composite map against which all potential conflicts are evaluated. Essentially, the composite map shows solar suitability where there are various levels of conflict. The user determines the level of solar suitability and the levels of conflict with one or more of the other models. Since the composite maps are based on the solar suitability model, the styling reflects that model's colors (purple to green), to avoid confusion with the other three conflict-based maps.

The composite dataset contains numeric results (or EEMS scores) for each model (-1.000 to +1.000), standardized rankings (very low to very high), and general conflict levels for the three value models. The dataset provides the maximum flexibility for easily obtaining information about the final model results – users are not restricted to a single outcome. The composite dataset allows users to assess any combinations on their own. For example, one may wish to explore the differences between various solar development suitability scores or ranks (**Figure 19**). The total area of very high and high ranked cells (very high and high solar suitability land) equals 2.9M acres (20.6% of the project area). Adding the moderately high ranked cells brings the total area up to 6.8M acres (almost half of the region has either very high, high, or moderately high solar suitability).

Table 5. *Summary statistics for suitability and general conflict levels based on the high-level results from the group EEMS models, based on the entire study area.*

Solar Development Suitability					
Score		Suitability Level	Cell ount	Acres	Percent
-1.000000	-0.250000	Low Suitability	38,888	2,402,355	16.87%
-0.249999	0.250000	Moderate Suitability	81,945	5,062,255	35.54%
0.250000	1.000000	High Suitability	109,709	6,777,411	47.59%
		Totals	230,542	14,242,020	100.00%

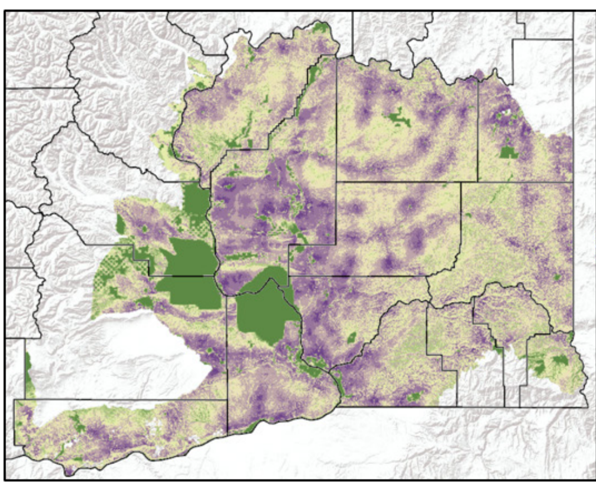
Farmland Value					
Score		Suitability Level	Cell Count	Acres	Percent
-1.000000	0.000000	Low Conflict	135,160	8,349,678	58.63%
0.000001	0.500000	Moderate Conflict	57,710	3,565,107	25.03%
0.500001	1.000000	High Conflict	37,672	2,327,235	16.34%
		Totals	230,542	14,242,020	100.00%

Ranchland Value					
Score		Suitability Level	Cell Count	Acres	Percent
-1.000000	0.000000	Low Conflict	124,207	7,673,043	53.88%
0.000001	0.500000	Moderate Conflict	89,057	5,501,607	38.63%
0.500001	1.000000	High Conflict	17,278	1,067,370	7.49%
		Totals	230,542	14,242,020	100.00%

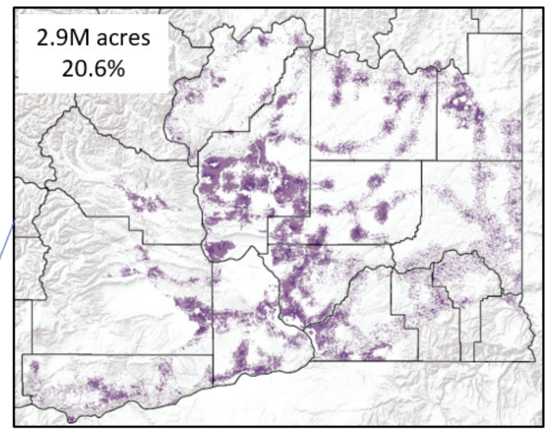
Environmental Conservation Value					
Score		Suitability Level	Cell Count	Acres	Percent
-1.000000	0.000000	Low Conflict	83,586	5,163,630	36.26%
0.000001	0.500000	Moderate Conflict	32,288	1,994,632	14.01%
0.500001	1.000000	High Conflict	114,668	7,083,759	49.74%
		Totals	230,542	14,242,020	100.00%

> The Solar Development Suitability Model serves as the foundation of the composite map against which all potential conflicts are evaluated.

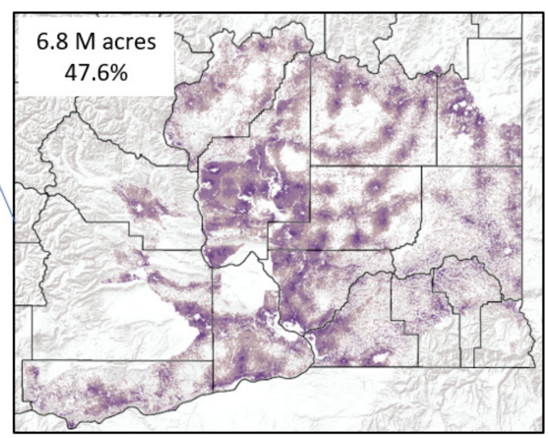
The results of evaluating how much of these 6.8M acres of solar development potential are also low conflict for each of the individual value models can be seen in **Figure 20**. In all three cases, the total areas of low conflict range from 43.5% to 47.7%. But when all three are looked at collectively, the remaining area is very small (211,954 acres – 3.13% of the suitable area) (**Figure 21**) and is largely concentrated adjacent to existing development in many locations. This makes sense as the highest value environmental conservation lands, farmland, and ranchland do not significantly overlap.



All Solar Development Suitability Ranks



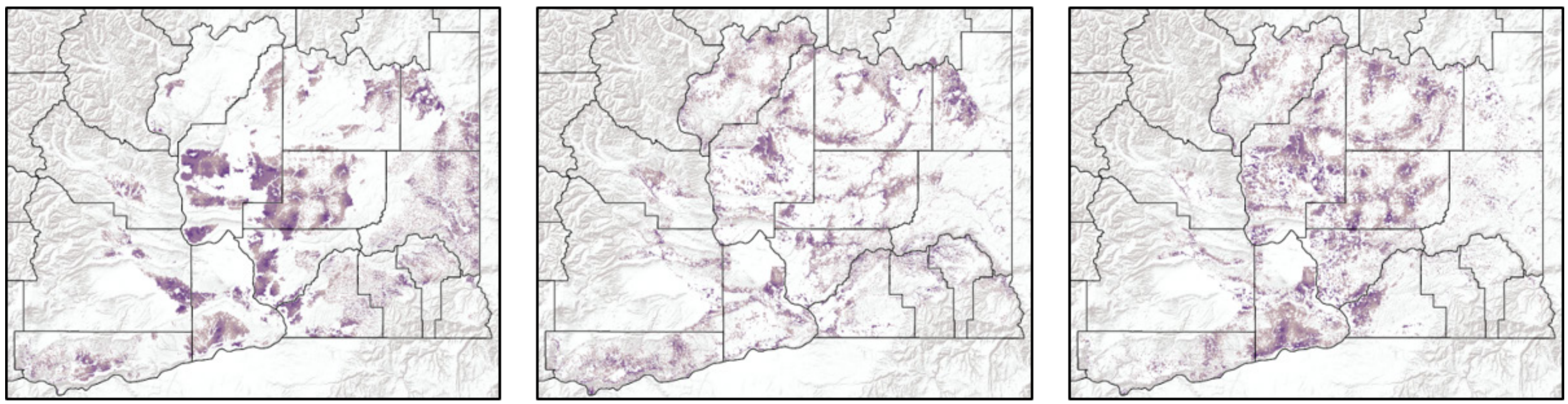
Very High and High Solar Development Suitability Ranks



Very High, High, and Moderately High Solar Development Suitability Ranks

Figure 19. *Composite map highlighting the higher solar development suitability areas.*

A. Environmental Conservation Value | B. Farmland Value | C. Ranchland Value



Low-conflict environmental conservation lands are 3.08M acres (45.5%) of the high solar development suitability lands

Low-conflict farmlands are 2.9M acres (43.5%) of the high solar development suitability lands

Low-conflict ranchlands are 3.2M acres (47.7%) of the high solar development suitability lands

Figure 20. *Composite map showing areas of solar development suitability ranked as very high, high, and moderately high (in purple) and (A) low-conflict environmental conservation lands, (B) low-conflict farmland, and (C) low-conflict ranchland.*

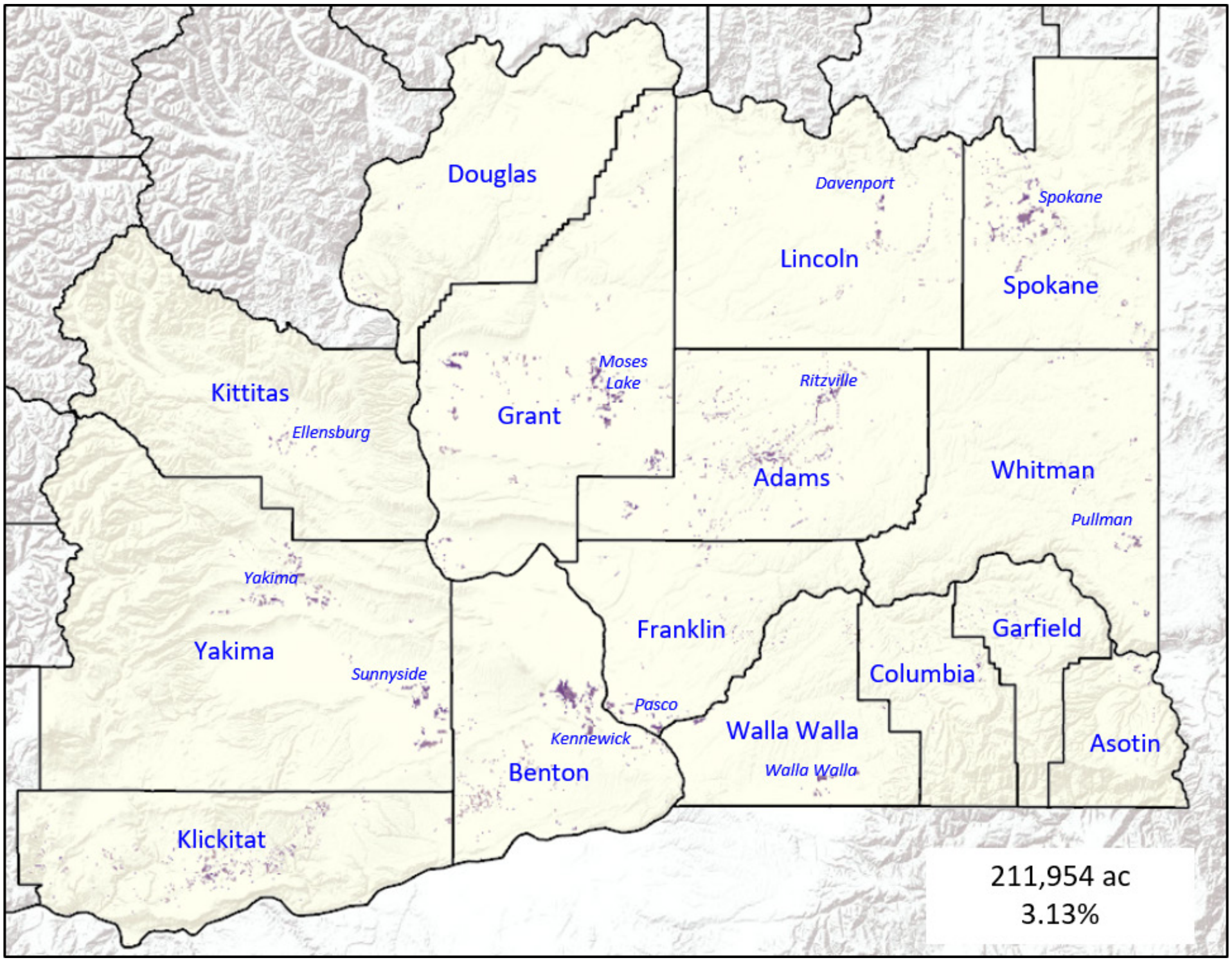


Figure 21. *Composite map showing areas of solar development suitability ranked as very high, high, and moderately high (in purple) plus low conflict for all other models combined.*

Using the Composite Model in the Gateway

The composite dataset provides the user with a great degree of flexibility. **Appendix A** provides instructions for using the composite dataset. Building on the previous example, users can use the FILTER command in the Gateway to explore any combination of settings included in the composite dataset **(Figure 22**). To illustrate a few additional examples of how results can change when different settings are chosen, we provide **Figure 23** through **Figure 25**. Keeping the same suitability area, **Figure 23** shows the area resulting from keeping environmental conservation and farmlands at a low conflict level and expanding the ranchland value to include low and moderate conflict. The area more than doubles from the results shown in **Figure 22**, increasing to 474,071 acres (6.99%). **Figure 24** shows the area resulting from keeping environmental conservation and ranchlands at a low conflict level and expanding the farmland value to include low and moderate conflict. Suitable area increases to 757,253 acres (11.17%). The last example (**Figure 25**) shows the area resulting from keeping environmental conservation at a low conflict level and expanding the farmland and ranchland value to include low and moderate conflict levels. The total area jumps to 1.6M acres (23.04%) of the suitable area. A summary of all four example scenarios is presented in **Table 6**.

Table 6. *Summary statistics for the four tested scenarios using solar development suitability ranked as very high, high, and moderately high.*

Scenario	Description	Acres	Percent of High Solar Suitability	Percent of Total Study Area
Scenario 1	Low conflict for all values	211,954	3.13%	1.49%
Scenario 2	Environmental Conservation: Low Farmland: Low Ranchland: Moderate	474,071	6.99%	3.33%
Scenario 3	Environmental Conservation: Low Farmland: Moderate Ranchland: Low	757,253	11.17%	5.32%
Scenario 4	Environmental Conservation: Low Farmland: Moderate Ranchland: Moderate	1,561,704	23.04%	10.9%

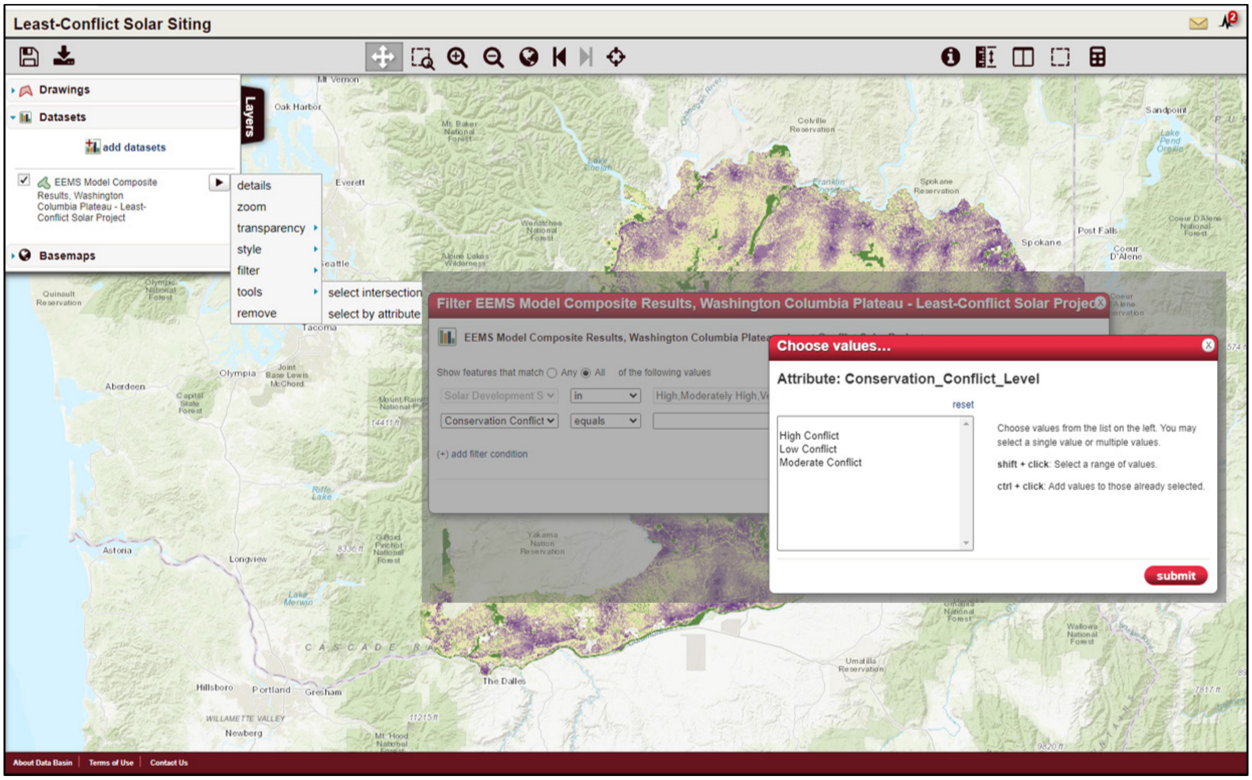


Figure 22. *Screen shot of the EEMS model composite results on the Gateway map page showing the location and interface of the editable Filter command.*

The composite dataset provides a simple way to explore numerous combinations of the relationships between solar suitability and the three value models.

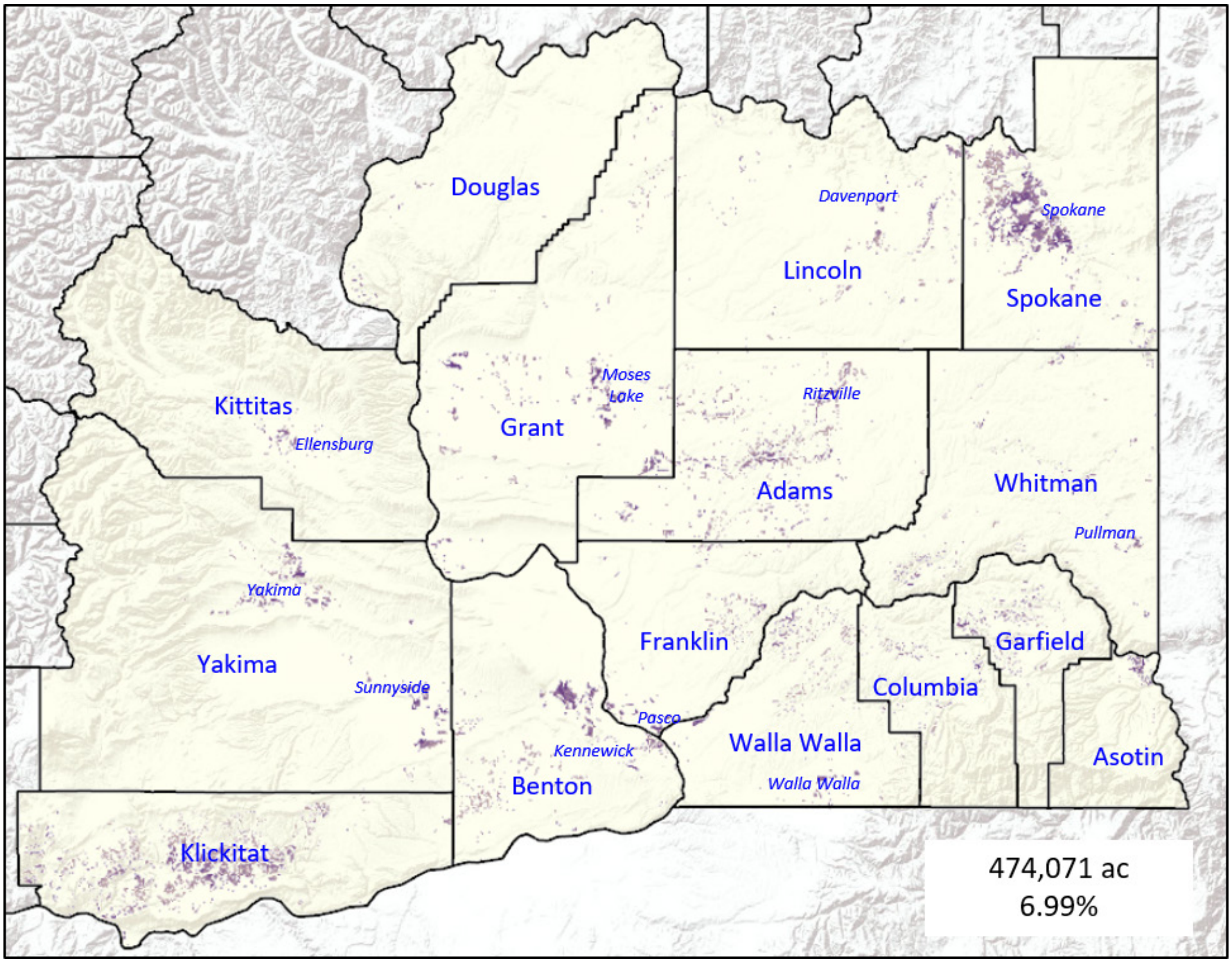


Figure 23. *Composite map showing areas of solar development suitability ranked as very high, high, and moderately high (in purple) which are also low conflict for environmental conservation and farmland, and low and moderate conflict for ranchland.*

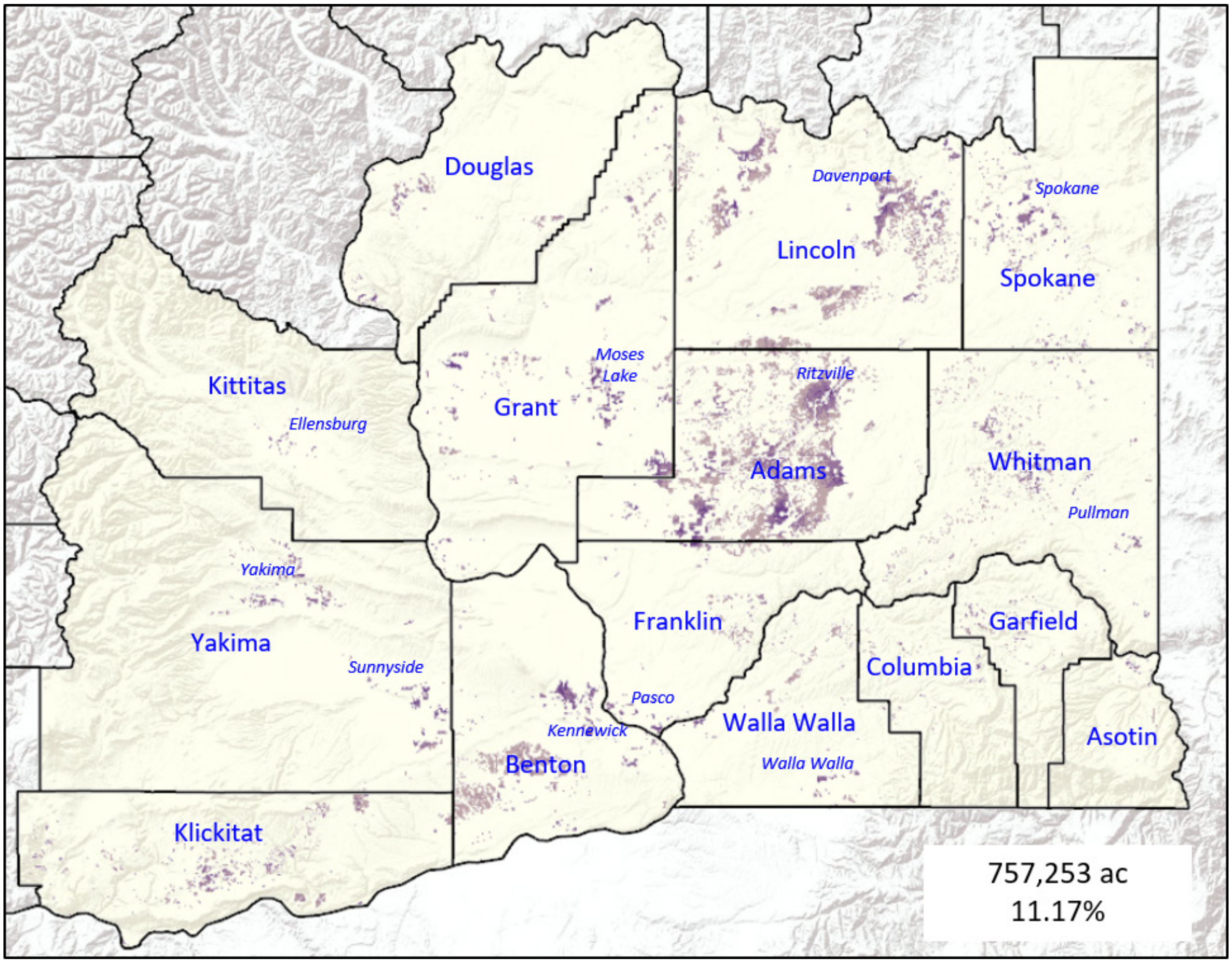


Figure 24. *Composite map showing areas of solar development suitability ranked as very high, high, and moderately high (in purple) which are also low conflict for environmental conservation and ranchland and low and moderate conflict for farmland.*

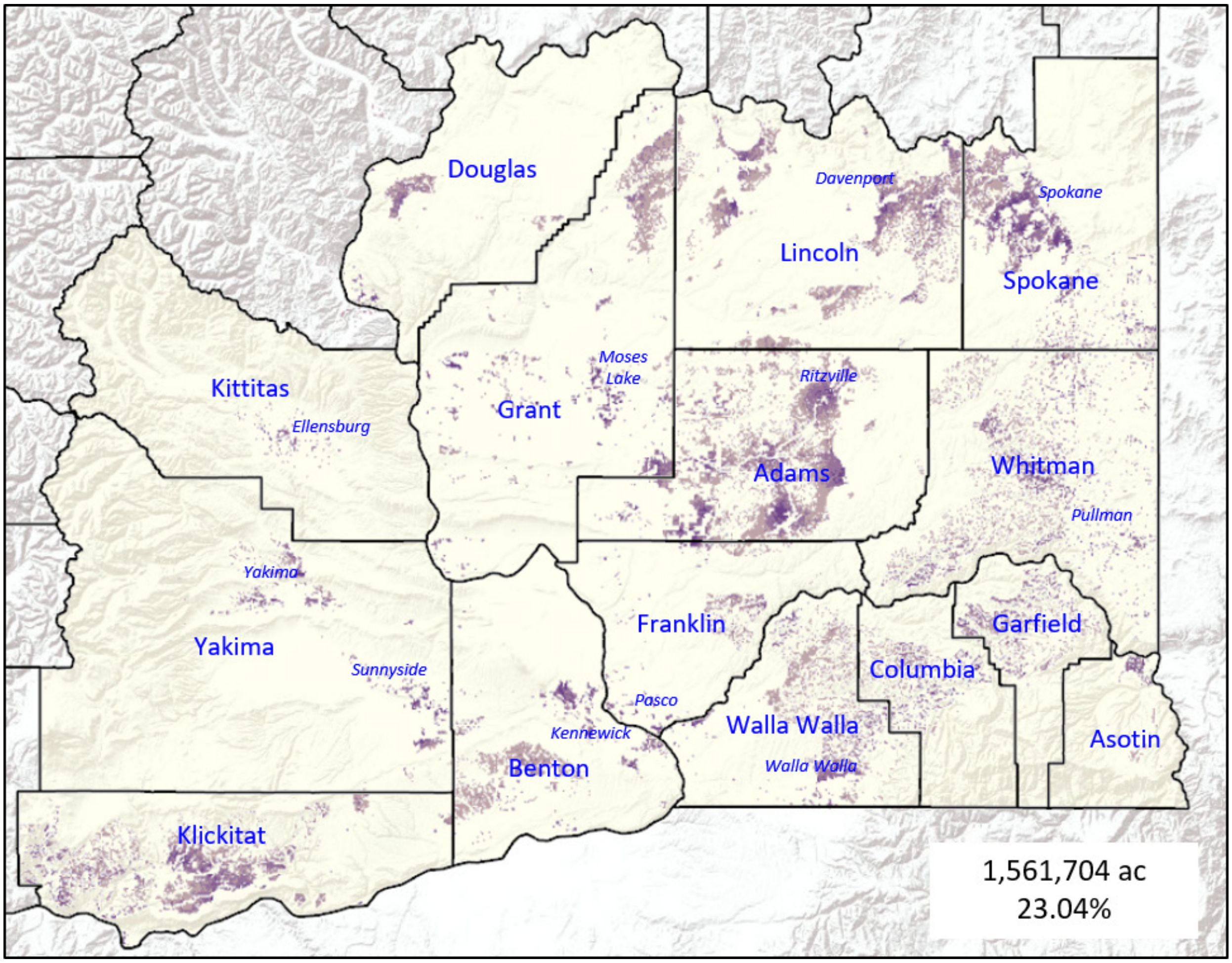


Figure 25. *Composite map showing areas of solar development suitability ranked as very high, high, and moderately high (in purple) which are also low conflict for environmental conservation and low and moderate conflict for both ranchland and farmland.*

The composite dataset provides a simple way to explore numerous combinations of the relationships between solar suitability and the three value models. Users can also combine the composite model with the different EEMS models on the Gateway. Used together, more detailed information regarding the specific conditions for a site can be learned. Using the "Identify" tool on the Gateway map page, users can click anywhere on the map and the system will retrieve information for all attributes in a pop-up screen at that specific location. Furthermore, the composite dataset can be viewed with other valuable datasets not included in the models but easily viewed in the Gateway (**Figure 26**). The presentation slides and video-recording from the third gathering have visual information on how to use both the composite maps and the individual maps in the Gateway.

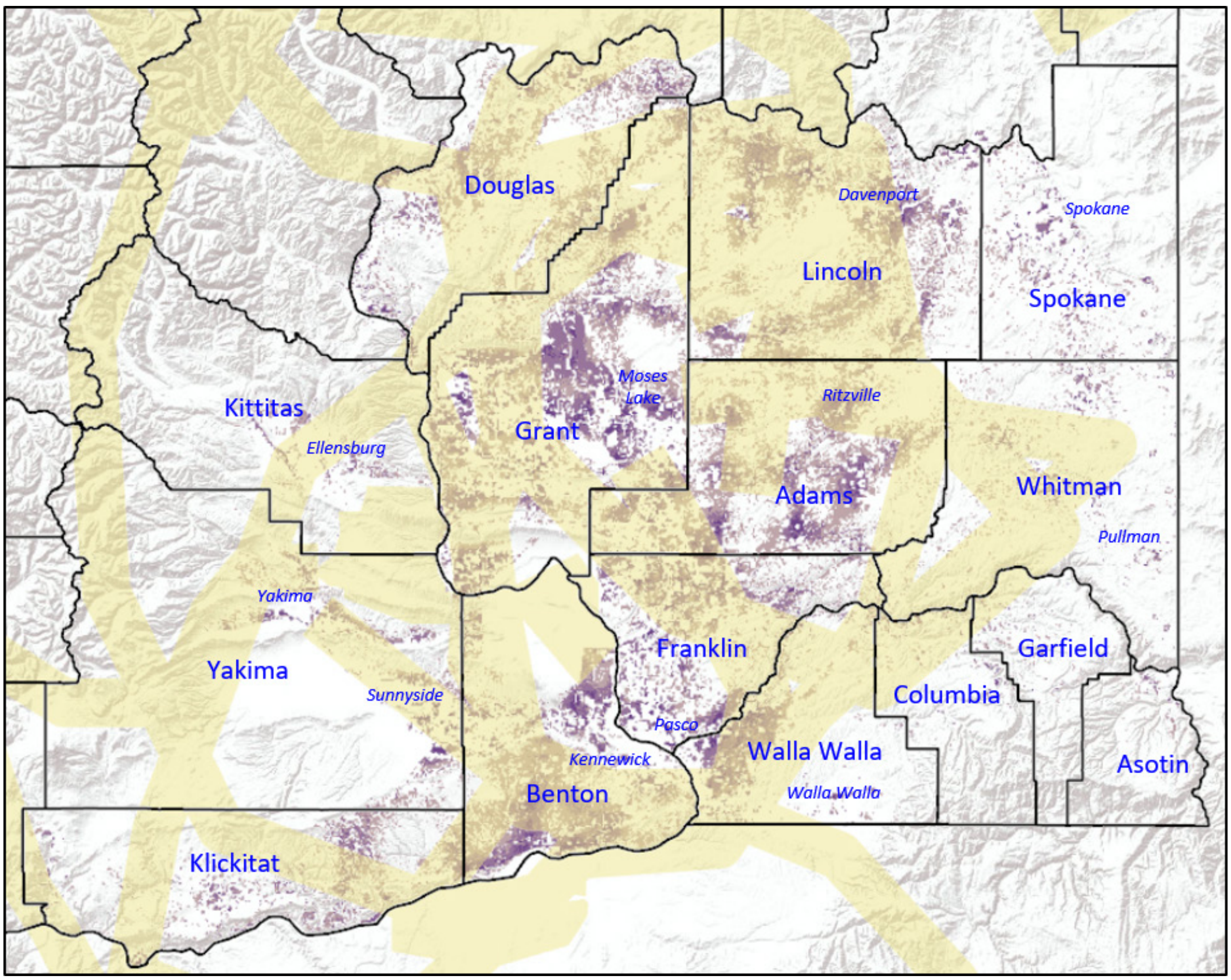


Figure 26. *Example of adding ancillary datasets (e.g., restricted airspace and military training routes in yellow) to provide more information to the previous map (in purple) in the Gateway.*

Photo by Dean White; courtesy of Washington State Conservation Commission

Conclusion

During the least-conflict solar siting project, mapping groups of knowledgeable volunteers worked collaboratively with the guidance of geospatial analysts to determine criteria for the least-conflict and solar suitability models and maps, provide datasets, review and revise various levels of output, and ultimately help create the final maps. Through this extended process, lands were identified that could potentially be used for solar PV developments with few, if any, disputes. (Least conflict does not mean no conflict.) Tribes, however, have not provided information about any of these lands, and they must be engaged early on about any location.

Farmland, ranchland, and environmental conservation lands were each ranked by potential low, moderate, or high conflict. Solar development suitability lands were ranked by high, moderate, and low suitability for development. Using digital maps accessible through the Washington Columbia Plateau Least-Conflict Solar Siting Gateway on the open-source free platform called Data Basin, users can assess different levels of conflict for any or all of the "land-uses" with different solar suitability levels. The transparency of the program allows a user to view the attributes, such as good soils, steep slope, or an important bird species, for any spot on the map. (Each "spot" is a 500m grid cell, which is approximately 62 acres.)This provides flexibility when considering if a site might be suitable for mitigation, or to discuss siting with a farmer whose soils and water are not optimal.

As an example of assessing different suitability levels, out of the study area of 14,242,020 acres (which does not include Tribal reservations), over 6,777,000 acres, or 47.6%, are deemed highly suitable for solar development by the criteria agreed upon by the solar industry mapping group. Of this highly suitable area, just under 212,000 acres, approximately 3.1%, are considered potential low conflict lands for the other land uses. This is about 1.5% of the total study area. When assessing low conflict environmental conservation lands and moderate conflict farmland and ranchland, this number increases to approximately 1,561,700 acres, 23% of the highly suitable solar land, or 11 percent of the total study area (see **Table 6** on page 60).

Additional datasets (maps) may be overlain to provide more information. For example, additional information may include where irrigation canals or socioeconomic data are in relation to possible solar projects.

The individual and composite maps have other uses for various agencies, organizations, developers, and landowners, such as providing: (1) information for creating non-project EISs for improved clean energy siting, as stipulated in a recent state bill written to promote clean energy while protecting natural resources and supporting communities; and (2) a starting point when engaging with Tribes. Other comments and concerns were brought up through large public Zoom gatherings and mapping groups; these important points can be read in the Mapping Process and Columbia Plateau Tribes sections of this report.

New and updated datasets can be added in the future to keep the mapping tool current. For this to occur, however, adequate funding and a managing entity would need to be identified for this purpose. Another potential tool could be produced by researching the viability of dual-use activities, such as crop production or grazing, with solar development in the Columbia Plateau region, and integrating the information with the least-conflict models and datasets to determine possible locations for future dual-use projects and research.

The least-conflict study was done with the expectation that the digital maps and mapping tools will continue to be used on the Washington Columbia Plateau Least-Conflict Solar Siting Gateway, to steer solar developers to areas of least conflict and protect the state's rich farmland, ranchland, unique habitats, endangered and threatened and otherwise important species, and Tribes' rights and natural and cultural resources.

The least-conflict study was done with the expectation that the digital maps and mapping tools will continue to be used on the Washington Columbia Plateau Least-Conflict Solar Siting Gateway.

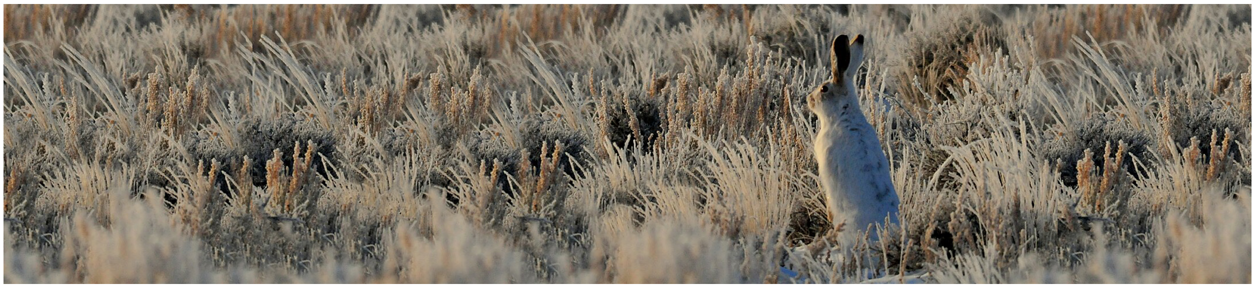


Photo by Tom Koerner, U.S. Fish and Wildlife Services

Appendix A
Using the Washington Columbia Plateau Least-Conflict Solar Siting Gateway

The Washington Columbia Plateau Least-Conflict Solar Siting Gateway was constructed using Data Basin technology that was developed by the Conservation Biology Institute. The system was designed around four main principles: (1) improve access to map-related content, (2) enhance data and information integration, (3) design a system that is easy to use without losing scientific or technical rigor, and (4) promote collaboration. The online platform is accessible using any of the popular web browsers. It can be used anonymously, but a free private account is necessary to unlock many of its more powerful features. Gateways are customized Data Basin platforms that are focused on a topic and/or geography, such as the Columbia Plateau Least-Conflict Solar Siting Gateway. Users can elect to stay completely in a gateway or access the entire Data Basin content if they choose.

What Can I Do in the Data Basin Gateway?

- Search the ever-expanding data library
- Import your own content
- Download available datasets
- Visualize spatial data – static and time-enabled
- Style most datasets
- Easily create, save, share, and export custom maps
- Control privacy of your data, maps, and activities
- Easily organize content of interest
- Create or participate in public or private working groups
- Use simple commenting and analytical tools
- Find experts
- Access other online resources, including associated applications

How Do I Create My Own Private Account?

Using your web browser, go to ***https://wsuenergy.databasin.org/***. At the right side of the top banner, there are two links: SIGN UP and SIGN IN. Click on the SIGN UP link and follow the instructions on the sign-up page (**Figure A-1**). You have several choices to create your private account. You can fill in the panels provided or you can use an existing account that you may have with Google©, Facebook©, Yahoo©, or USGS. Once you have your own account, you simply click the 'Sign In' link and login with your account username and password. Going forward, all of your activities in the system will be summarized on your private Workspace Home page. The system will automatically keep track of all your bookmarks, groups memberships, datasets you have uploaded, datasets you have recently viewed, and maps you have made, to name a few. A single account will provide access to all of Data Basin and all of its public gateways.

Figure A-1. *Screenshot of the Data Basin Gateway sign-up page.*

What Kind of Information is in The Gateway?

Data Basin manages seven different content types. Datasets form the basic currency of the system, but six other types are also important and can be searched and viewed. Included in the table below are the number of each content type for the larger Data Basin system at the time of this writing. Numbers for each content type increases daily.

Table A-1. *Data Basin content types.*

	DATASETS – Individual spatial data files (~35,000 in Data Basin)
	MAPS – Customized maps made by members using the platform (>17,000 in Data Basin)
	GALLERIES – Collections of datasets and/or maps (~1,200)
	GUIDES & CASE STUDIES – Explanations and examples of addressing different topics with maps (165)
	GROUPS – Created by members to address specific issues (>1,200)
	MEMBERS – Number of individual user accounts (~48,000)
	DOCUMENTS – All non-spatial files (e.g., PDFs, Excel, Word, PowerPoint) (> 2,250)

How Do I Get Started Working in The Gateway?

There are several ways users can get started using the system. The main landing page has been organized to help users access project highlights as quickly as possible.

Organized Galleries

Across the middle of the landing page are five panels with representative images. Clicking each of the images will open a specific gallery. The first four galleries correspond to the project mapping groups. These galleries are organized with a map containing the final model appearing at the top of the GALLERY CONTENT panel, below which are two folders. One folder contains all of the inputs (datasets) to the model and the other contains other potential datasets of interest. The last gallery on the landing page is entitled "Columbia Plateau Popular Datasets" and contains 60 datasets that were not included in any of the models, but which provide valuable contextual information when viewed in conjunction with the models. This gallery contains datasets on cultural resources, socioeconomics, military uses, and political boundaries to name a few.

Quick Start Map

At the bottom of the landing page, there is a QUICK START MAP that when clicked will take the user to the Data Basin map page with a few preloaded datasets. The intent is to provide users with an easy way to explore the different mapping features.

Featured Content

Also at the bottom of the landing page is a FEATURED CONTENT carousel. This is another way a user can quickly access some of the most important datasets and maps in the Gateway.

Browse and Search

If you just want to look through the data library, you can click on a content type label from the EXPLORE drop-down menu. If you prefer trying to locate something specific, a SEARCH box is located in the upper right corner of the landing page. A search request can focus on keywords, geography, or both, and it queries all of the managed content – not just individual datasets (**Figure A-2**). Keyword searches can be simple or complex. The default search pool is the Gateway; however, users can select a different search pool (**Figure A-3**). Note the difference in results (red box).

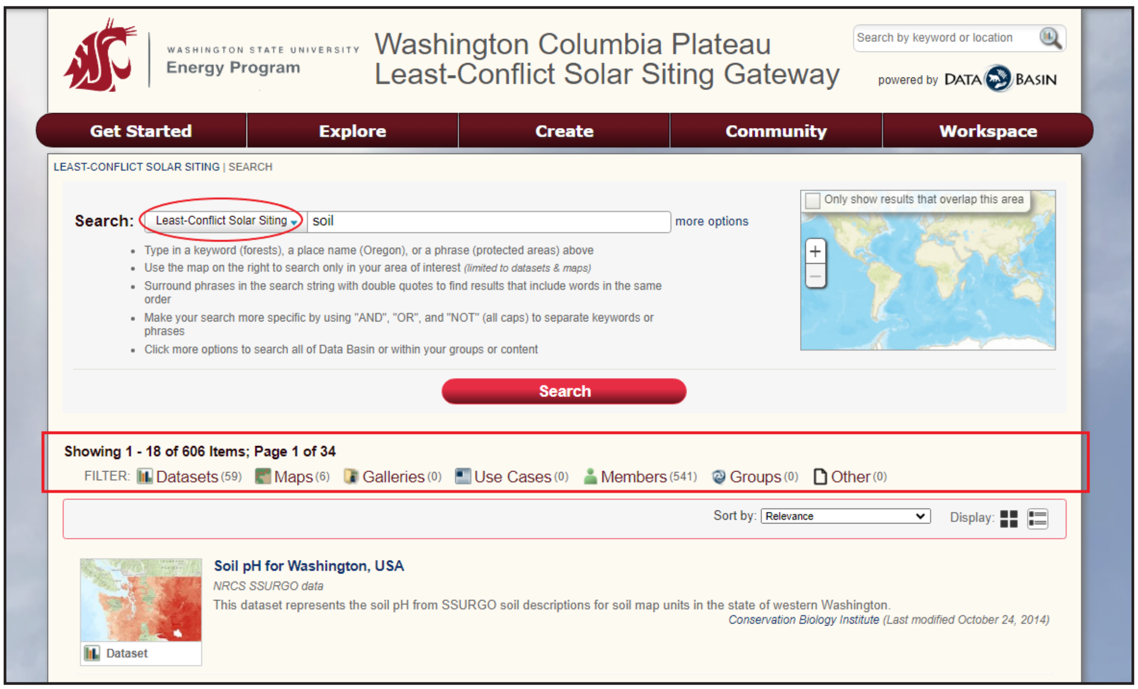


Figure A-2. *Example search results using the keyword soil in the Gateway content pool.*

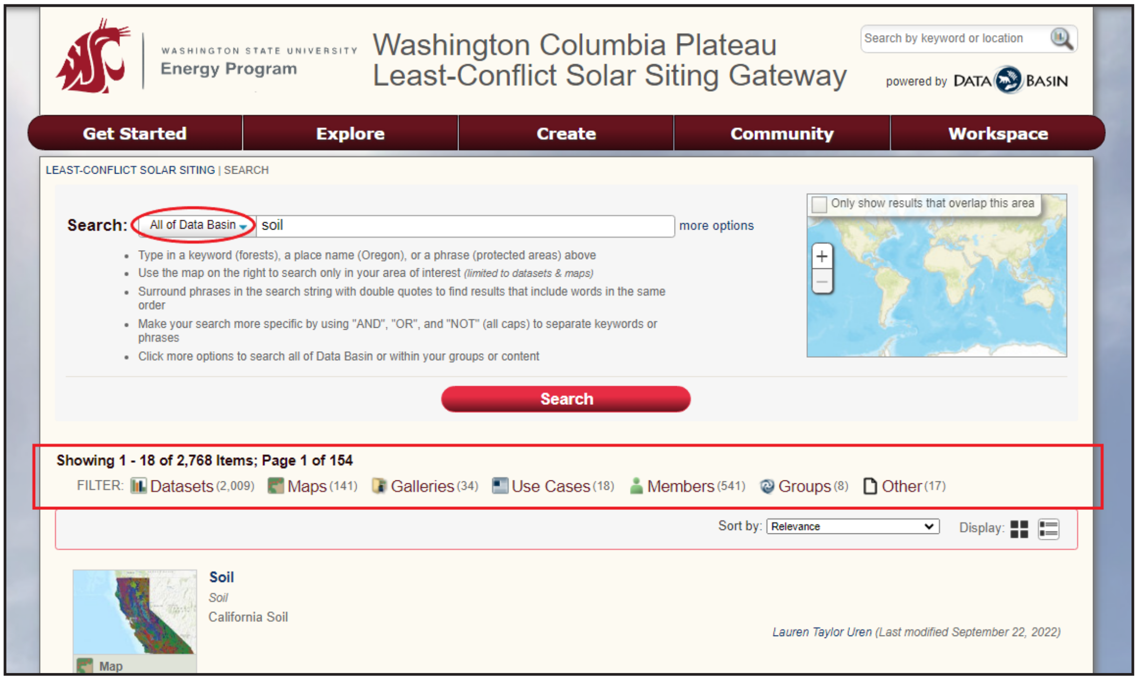
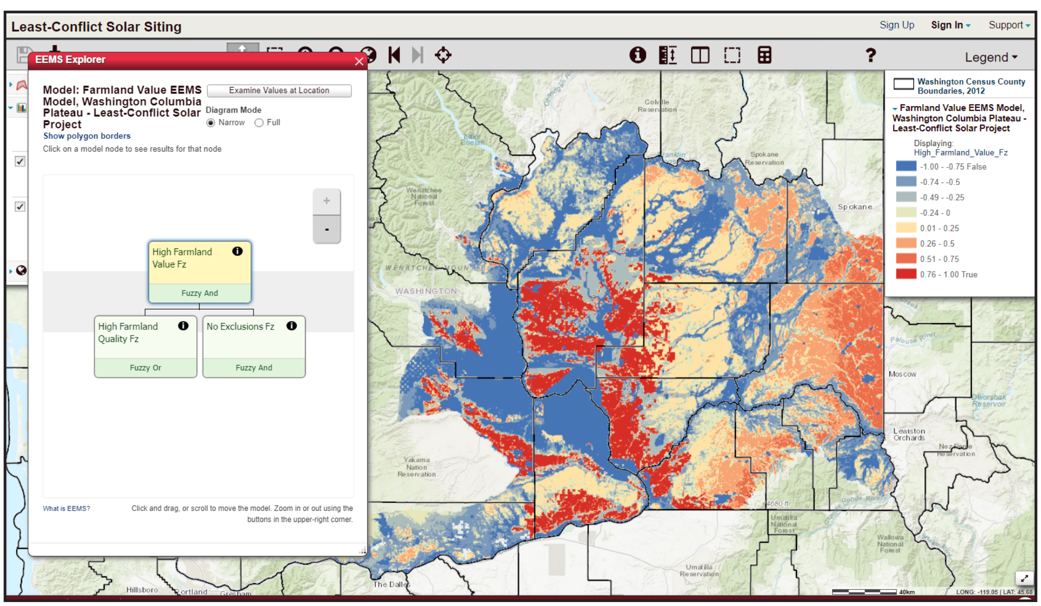


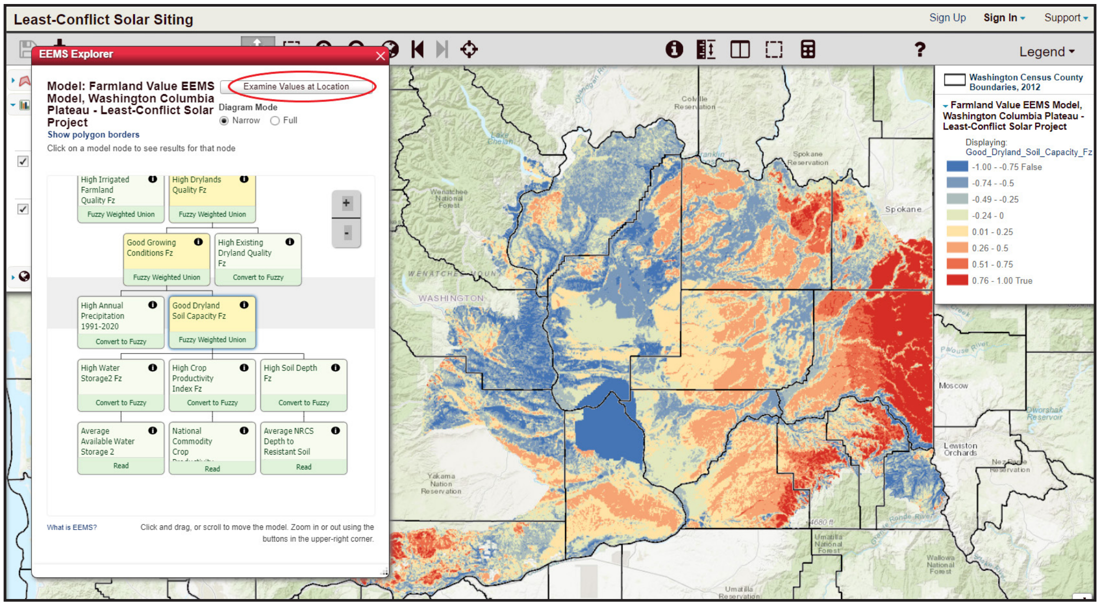
Figure A-3. *Example search results using the keyword soil from the larger Data Basin content pool.*

How to Explore EEMS Models in the Data Basin Gateway

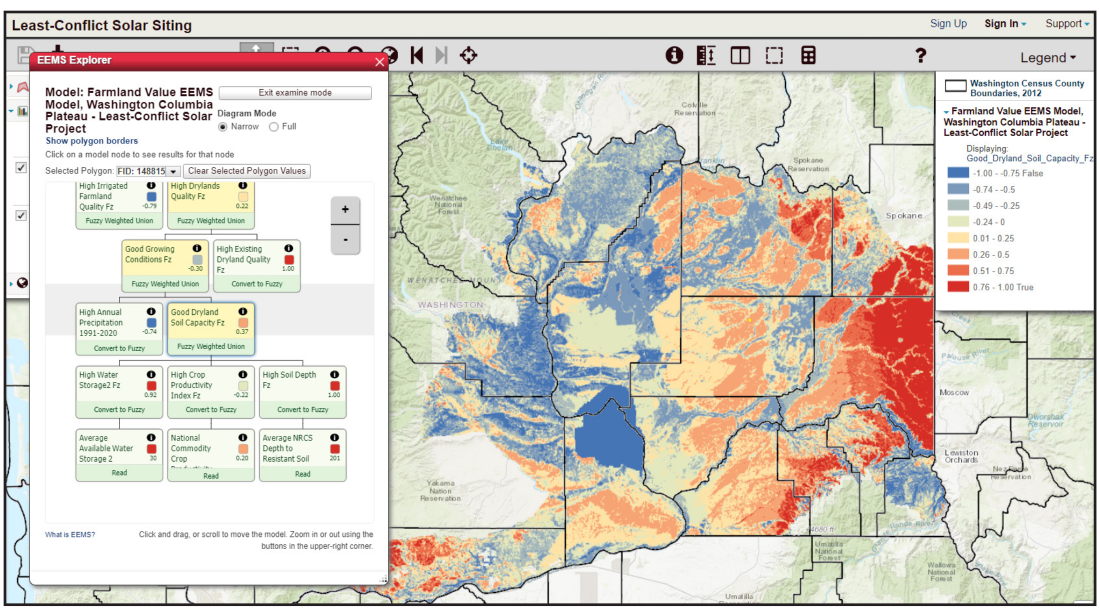
1. Select any of the four EEMS model datasets or any map that contains one or more of them (e.g., Farmland Value EEMS Model, Washington Columbia Plateau – Least-Conflict).
2. Click on OPEN IN MAP
3. The dataset will be visible along the left margin of the page.
4. Click on the green icon with the red border that appears next to the dataset title.



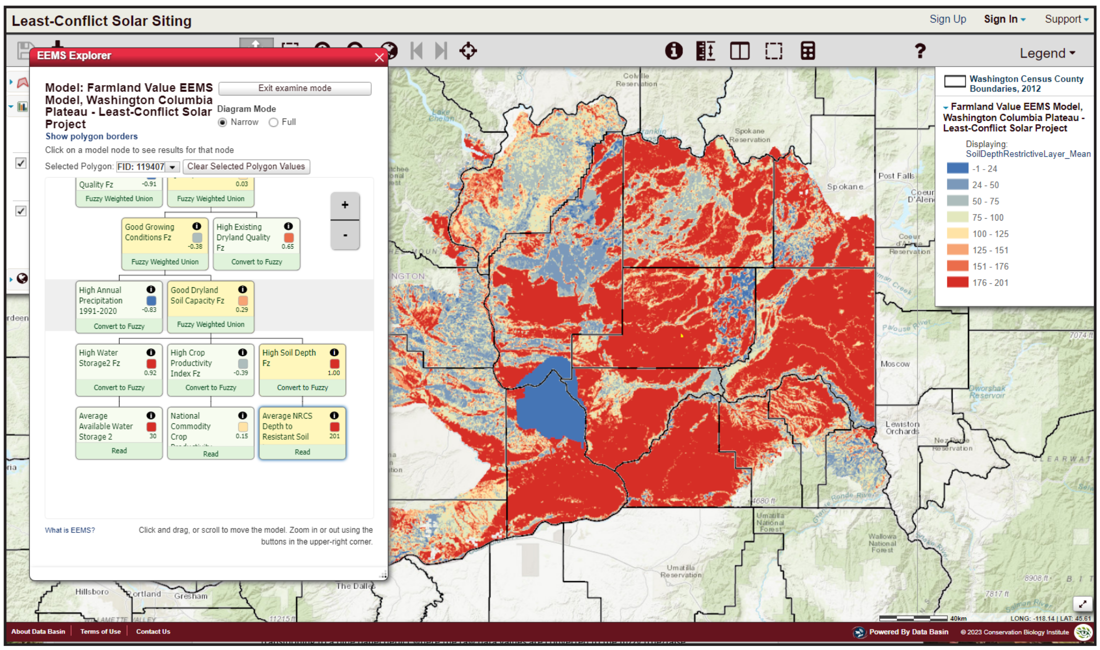
5. An EEMS Explorer pop-up panel will appear on screen.
6. You can then click on any map panel on the expandable tree diagram to visualize any one you wish to see (e.g., Good Dryland Soil Capacity).



7. You can explore as many map panels as you like, and the map will change automatically.
8. You can also query the numeric values for every map panel for any location. Click on the EXAMINE VALUES AT LOCATION button at the upper right of the pop-up screen and then click anywhere on the map.



9. Notice that the numbers in each map panel in the diagram display the appropriate associated color.
10. Note that not all of the values are between 1.00 and -1.00. This standard only holds true for those panels above the panels that are labeled "Read," which are usually the bottom panels. The map panels with Read at the bottom contains raw values. The color styling is kept the same as it gives some indication of where a particular value occurs along a range of values. If you click on any of these panels, the color range stays the same, but the new value legend will appear in the Legend panel at the upper right of the map page.

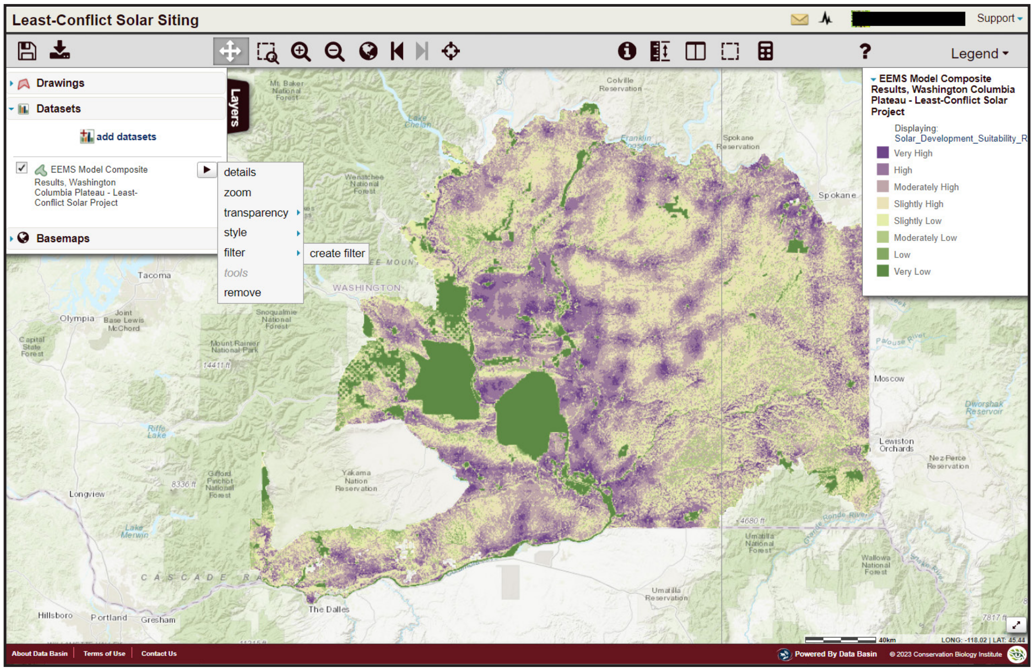


How to Use the Composite Dataset

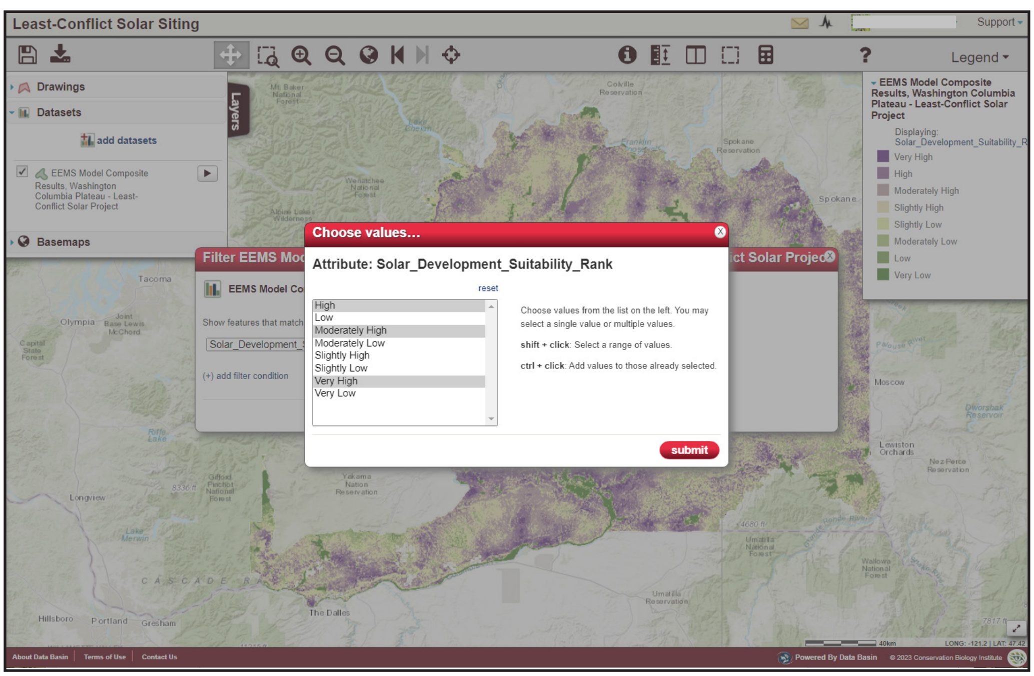
The composite dataset that integrates all four EEMS models (EEMS Model Composite Results, Washington Columbia Plateau – Least-Conflict Project) is one of the main digital end products of the project. Even though the dataset integrates EEMS models, it is not an EEMS model itself. Instead, it pulls high-level findings into a single dataset so the relationships between the models can be easily evaluated.

The foundation of the dataset (including the styling) is the solar development suitability results (EEMS score and rank) with three results (EEMS score, rank, and conflict level) for each of the value EEMS models. To work with the dataset:

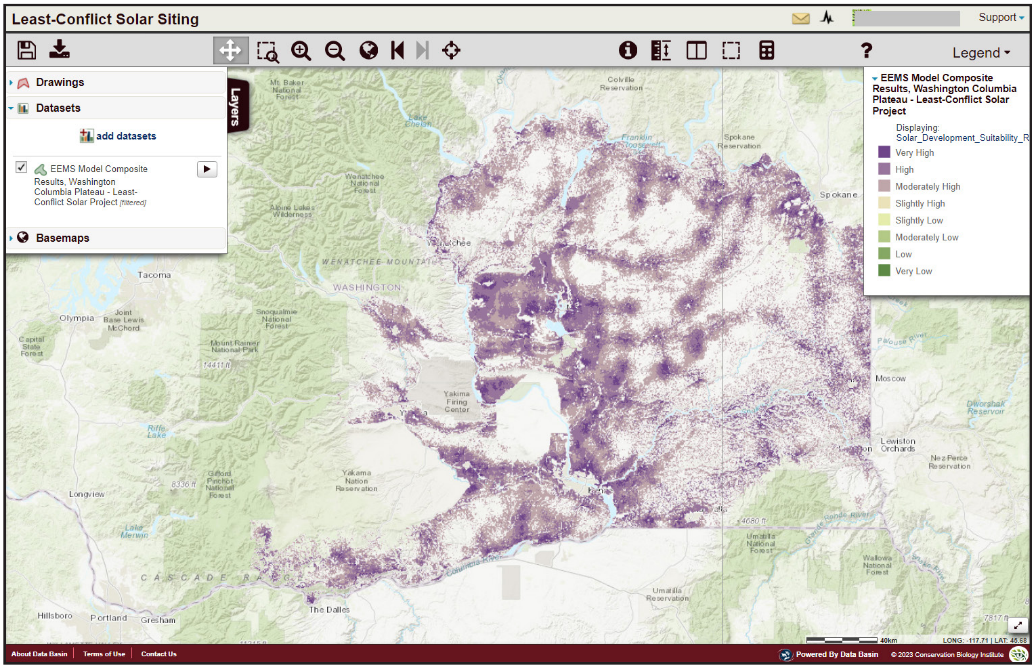
1. Open the composite datasets on the map page.
2. From the options arrow next to the dataset title, select CREATE FILTER.



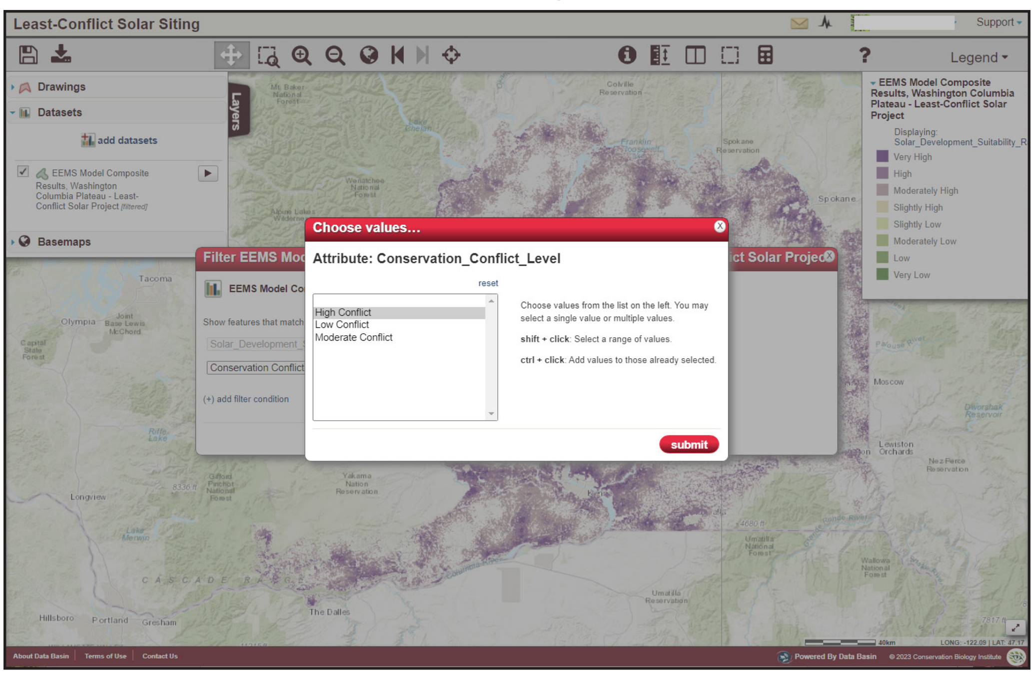
3. From the pop-up screen, select the attribute(s) and settings to filter. For example, Solar Development Suitability Rank (in the example below) = Very High, High, or Moderately High.



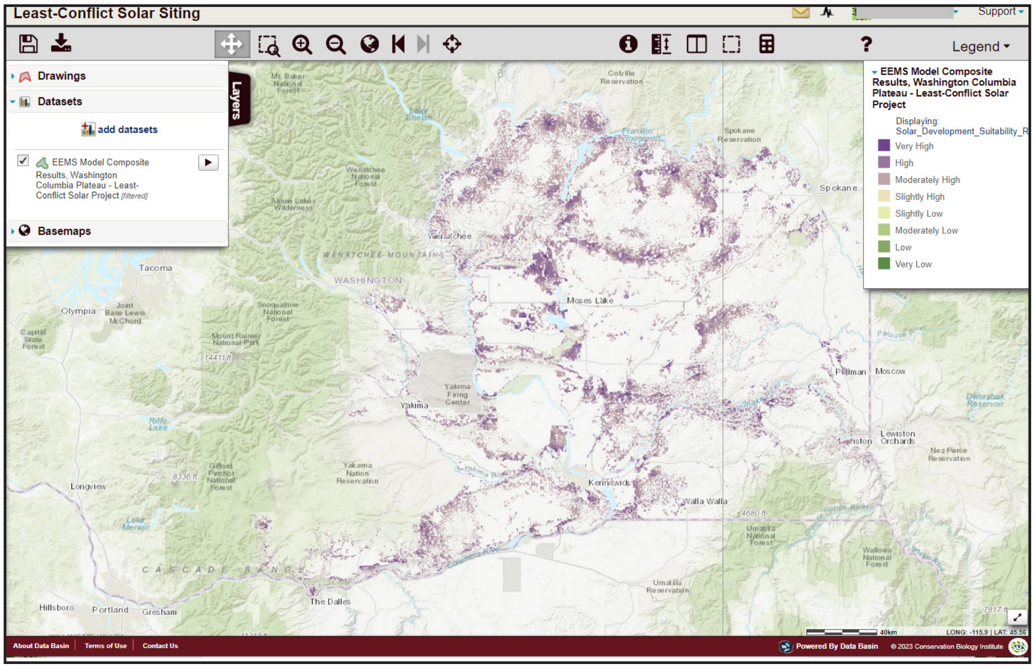
4. After the red SUBMIT button is clicked, the "Matching Features" displayed in the lower right reports how many cells meet the set criteria (in this case, it should be 109,709 cells or 6,771,411 acres).
5. If the second red SUBMIT button is clicked, the map will display the results from the filter.



6. Additional filtering criteria can be added to address a wide range of relationships between the different models, especially between solar development suitability and one or more of the value results. Any of the attributes can be used to define the custom filter. From the standpoint of the value models, EEMS score, rank, or general conflict level can be used.



7. When the two red SUBMIT buttons are clicked, the map changes to reflect the filtered criteria.



How Can I Get Help on How to Use the Gateway?

Under the GET STARTED drop-down on the landing page, there are several ways to get additional help. There is a FAQ option that answers popular questions, but the most useful option is to select VIEW VIDEO TUTORIALS. There are a dozen YouTube videos that focus on different topics. The top two provide a guided tour of Data Basin (GET STARTED WITH DATA BASIN and DETAILS OF DATA BASIN) and are considerably longer than the others. The other help topics include:

- Overview
- Searching
- Using Groups
- Creating a Map
- Creating a Gallery
- Importing Data
- Importing NetCDF Data
- Using the Swiper Tool
- Using My Workspace
- Commenting

Photo by Randy Stevens; courtesy of Washington State Conservation Commission

Appendix B
Enviromental Evaluation Modeling System Software

Simply put, fuzzy-logic allows you to assign shades of gray to thoughts and ideas rather than being limited to binary (black and white) determinations, which are more commonplace. It is this concept of "partial truth" which allows fuzzy-logic models to capture nuances more accurately during analysis and more closely resemble human patterns of thought.

Environmental Evaluation Modeling System (EEMS) fuzzy-logic models are hierarchical – that is, data flows up from the bottom of a tree diagram in order to answer a primary question at the top of the logic tree. Each map panel (or node) in the model structure represents a proposition. A proposition is simply a statement that can either be totally true (+1.00), totally false (-1.00), or somewhere in between at any given location. For all of the model diagrams provided in the report, a change from a gray panel to a blue panel indicates the transition from raw inputs to the "fuzzy" state in the model. Also, all inputs are organized by the chosen model resolution.

For example, if the proposition is "High Soil Moisture," a value of +1.00 at a specific location would indicate that this statement is totally true at that location. A value of -1.00 at a different location would indicate that this statement is totally false (i.e., that there is the lowest possible level of soil moisture in the study area). And values in between these two extremes represent degrees of truth along a continuum, and can be interpreted as follows:

- Values greater than zero indicate that the proposition is more true than false.
- Values equal to zero indicate that the proposition is neither true nor false.
- Values less than zero indicate that the proposition is more false than true.

The fuzzy (truth) values for each proposition get combined up the logic tree using various fuzzy-logic operators (e.g., OR, AND, UNION) in order to calculate the fuzzy value for the node directly above. In the example model diagram shown in **Table B-1**, High Soil Moisture is defined as the combination of High Soil Water Holding Capacity and Low Evapotranspiration. Both of these maps are derived from the raw data units of measurements. A UNION operator, which averages the two inputs equally, was used to logically combine the inputs.

The logic tree diagram provides the overarching arrangement and relative values of the various spatial datasets used to answer the primary question. Logic operators are the next most important driver of model results, but they are not the only settings that can influence the model outcome. Besides logic operators, users can alter "convert to fuzzy" thresholds, which can be more sophisticated than simply linear. For example, soil pH is an important soil attribute where middle-range pH values around 7 along a 0-14 range are the most valuable for most agricultural crops. A linear relationship representing the pH scale (0=false and 14=true) would not represent reality. A better approximation is a curve that represents false values occurring on both ends of the spectrum while the truest values occur closer to the mid pH ranges. Assigning different weights at various locations can also be very powerful. Finally, users have the means to block certain branches or inputs of the model.

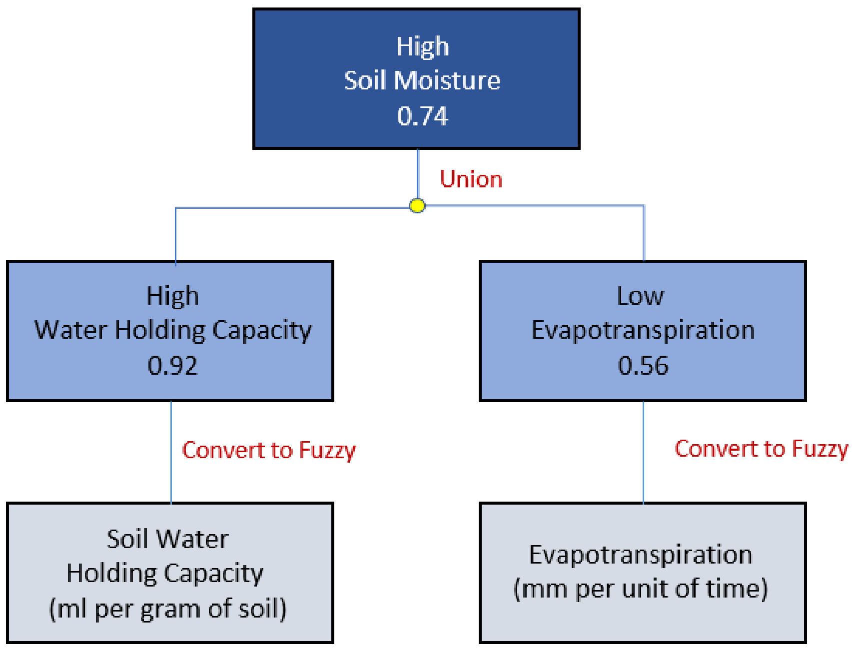


Figure B-1. *Simple EEMS diagram demonstrating how fuzzy values for Soil Water Holding Capacity and Evapotranspiration are combined to create a map of High Soil Moisture.*

What Logic Operators are Available in EEMS and What Does Each One Do?

Logic operators are organized into two types. One set of operators apply to raw input nodes, and the other set of operators apply to all logic commands for panels that have been represented by the true/false (or fuzzy) continuum. **Table B-1** provides a list of operators used in the models by one or more of the mapping groups.

The EEMS software can be downloaded at no charge along with the latest EEMS manual, which contains a full description of the latest software updates: ***https://eemsonline.org***. For an introduction to EEMS in ArcGIS, an explanation of the fuzzy logic concepts, and a demonstration of the EEMS Model Explorer, please view the EEMS recorded webinar.

Table B-1. *List of EEMS operators, input data classes, and descriptions used in the project.*

Operator	Input Data	Description
CONVERT TO FUZZY	Raw	Converts a field's values into fuzzy values.
MAXIMUM	Raw	Finds the maximum for each row of the input fields.
MINIMUM	Raw	Finds the minimum for each row of the input fields.
SUM	Raw	Computes the sum of the inputs.
WEIGHTED MEAN	Raw	Finds the weighted mean for each row of the input fields.
WEIGHTED SUM	Raw	Finds the weighted sum for each row of the input fields. Multiplies each field by its weight before adding.
AND	Fuzzy	Finds the minimum value of the inputs.
OR	Fuzzy	Finds the truest value of the inputs (maximum value).
SELECTED UNION	Fuzzy	Finds the union value (mean) of the specified number of TRUEest or FALSEest inputs.
UNION	Fuzzy	Finds the union value of the inputs (mean value).
WEIGHTED UNION	Fuzzy	Finds the weighted union (mean) for each row of the input fields.

Photo by L. Shields; courtesy of Washington State Conservation Commission

Appendix C
Detailed Data Lists

The following tables contain information on the spatial data inputs used in each of the group models:

Table C-1: Solar Suitability Model
Table C-2: Farmland Value Model
Table C-3: Ranchland Value Model
Table C-4: Environmental Conservation Value Model

The tables contain four columns: *Model Reference*, *Dataset Title*, *Source*, and *Data Basin Gateway Link*. In order to view the electronic map version of the dataset in the Gateway, simply click on the provided URL. The first column (Model Reference) contains an orange number that corresponds to the associated number in each of the model diagrams in the body of the report.

Table C-1. *List of Spatial Datasets used in the creation of the* **Solar Development Suitability Model** *including reference numbers to the model diagram, dataset titles, sources, and links to the Data Basin Gateway.*

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	A.Good Terrain Suitability		
1	Aspect-Slope, Washington Columbia Plateau	LANDFIRE, EROS, U.S. Geological Survey	*https://wsuenergy.databasin.org/datasets/754ace79008d453fa928b7eafbec8e5a/*
2	gNATSGO – Percent Rock, Washington Columbia Plateau	USDA, Natural Resources Conservation Service	*https://databasin.org/datasets/c2f3c282599b4405a31d073594333 9a3/*
3	SSURGO Soil Survey - Percent Clay Washington	USDA, Natural Resources Conservation Service	*https://wsuenergy.databasin.org/datasets/2af35ef7d321427b9194eb982c068737/*
	B. Low Hazards		
4	Seismogenic Features (Faults and Earthquakes), Washington	Washington Geological Survey	*https://wsuenergy.databasin.org/datasets/f2e7d56ba4884eacbb2f27ac55f9b42d/*
5	Oregon and Washington Wildfire Perimeter History (1900-2014)	Bureau of Land Management & U.S. Forest Service	*https://wsuenergy.databasin.org/datasets/5cde69a7c6064a0ebf31549b45904e61/*
5	Interagency Fire Perimeter History - Current Decade	National Interagency Fire Center	*https://wsuenergy.databasin.org/datasets/9396b26227ab44b4bbf8c75ae4113ead/*

Table C-1. *Continued*

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	C. Close Proximity to Infrastructure		
6	Functional Class Data for Non-State Routes in Washington (WSDOT)	Washington State Department of Transportation	*https://wsuenergy.databasin.org/datasets/462b4a2425b844e1a845b82d8035f02e/*
6	National Highway System for Non-State Routes in Washington (WSDOT)	Washington State Department of Transportation	*https://wsuenergy.databasin.org/datasets/bc1c05fd1aad4d058486becb7992797e/*
6	State Routes in Washington (WSDOT)	Washington State Department of Transportation	*https://wsuenergy.databasin.org/datasets/1c85677ab0c44778b5bab322904a841b/*
7	Electric Substations, Washington	Washington State Department of Commerce - CESA	*https://wsuenergy.databasin.org/datasets/36e74994140143e09bf72d2b586ce681/*
8	Electric Power Transmission Lines, Washington	Washington State Department of Commerce - CESA	*https://wsuenergy.databasin.org/datasets/b929f9fd76704af091d536b2b355d5ab/*
	D. Exclusions		
9	National Land Cover (NLCD) 2019, Washington Columbia Plateau	U.S. Geological Survey	*https://wsuenergy.databasin.org/datasets/5b20dbdc66ff4e61b88d3616197ef003/*
10	Hanford Comprehensive Land-Use Plan Environmental Impact Statement Designations	Bechtel Hanford, Inc.	*https://wsuenergy.databasin.org/datasets/0df2e1b33ee644e9acd25a022f884d67/*
11	Washington State Hydrography - NHD Waterbodies	U.S. Geological Survey	*https://wsuenergy.databasin.org/datasets/911b2606ab2a44c9aaabe1c4af86f676/*
12	Wetland Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/91fd421088084c3cb251b6f14cde5efb/*
13	Protected Areas Database of the United States (PAD-US) 3.0 Washington	U.S. Geological Survey	*https://wsuenergy.databasin.org/datasets/33ee4572d2be497987005f90a55e9ac7/*

Table C-2. *List of Spatial Datasets used in the creation of the* **Farmland Value Model** *including reference numbers to the model diagram, dataset titles, sources, and links to the Data Basin Gateway.*

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	A. High Drylands Quality		
1	Annual Precipitation 1991-2020 (PRISM), Washington Columbia Plateau	Oregon State University	*https://wsuenergy.databasin.org/datasets/bbec5c5f8c704311bc237f143cf31aef/*
2	gNATSGO - Available Water Storage, Washington Columbia Plateau	Natural Resources Conservation Service	*https://wsuenergy.databasin.org/datasets/3b3e5c60ff194bcabb92d761e81d8f48/*
3	gSSURGO - National Commodity Crop Productivity Index, Washington Columbia Plateau	Natural Resources Conservation Service	*https://wsuenergy.databasin.org/datasets/ecbb5c14614d4fd18bcd2a25f1b34b3a/*
4	gSSURGO - Depth to Soil Restrictive Layer, Washington Columbia Plateau	Natural Resources Conservation Service	*https://wsuenergy.databasin.org/datasets/b5224d68cf18421c9e1b12b4415ae777/*
5	Conservation Reserve Program Lands (2022), Washington Columbia Plateau	Washington State Department of Agriculture	*https://wsuenergy.databasin.org/datasets/bfc48e59b94848b4adb1ad62e777be7b/*
6	Dryland Crops (2022), Washington Columbia Plateau	Washington State Department of Agriculture	*https://wsuenergy.databasin.org/datasets/29977dc8a67d42cf9af4f94af0752c7d/*

Table C-2. Continued

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	B. Irrigated Farmland Quality		
7	Irrigation Districts and Buffered Canals and Ditches, Washington Columbia Plateau	U.S. Geological Survey (NHD) - CBI	*https://wsuenergy.databasin.org/datasets/e69334673c0a4ee78bb3b3df76a032a9/*
7	Groundwater Wells GWIS, Washington Columbia Plateau	Washington State Department of Ecology	*https://wsuenergy.databasin.org/datasets/242d27981ebe492e85612302dd0a214e/*
8	Irrigation Districts, Washington Columbia Plateau	Multiple Sources	*https://wsuenergy.databasin.org/datasets/64a84da20f204754b6148d7450f2ce0d/*
9	gNATSGO - Irrigated Capability Class,Washington Columbia Plateau	Natural Resources Conservation Service	*https://wsuenergy.databasin.org/datasets/7a87260b5f9f4b1592a923e2385a84f6/*
10	gNATSGO - Available Water Storage, Washington Columbia Plateau	Natural Resources Conservation Service	*https://wsuenergy.databasin.org/datasets/3b3e5c60ff194bcabb92d761e81d8f48/*
11	Soil Organic Carbon, Washington Columbia Plateau	OpenLandMap	*https://wsuenergy.databasin.org/datasets/d41474b248af455dbbea65c669aa4245/*
12	Irrigated Crops (2022), Washington Columbia Plateau	Washington State Department of Agriculture	*https://wsuenergy.databasin.org/datasets/0e7fa949f8a84673befa3839e409be78/*
	C. Exclusions		
13	City Limits, Washington Columbia Plateau	Washington State Department of Labor and Industries	*https://wsuenergy.databasin.org/datasets/7eb016f6ec0642bc92449acf75683c4b/*
14	Perennial Water - NHD, Washington Columbia Plateau	U.S. Geological Survey (NHD)	*https://wsuenergy.databasin.org/datasets/84a76ff1dcc74fd9bc6fac4c48808 9a1/*
15	Protected Areas, Washington Columbia Plateau	Conservation Biology Institute	*https://wsuenergy.databasin.org/datasets/a0c87e943bd84d55a61c92b67509fb65/*

Table C-3. *List of Spatial Datasets used in the creation of the **Ranchland Value Model** including reference numbers to the model diagram, dataset titles, sources, and links to the Data Basin Gateway.*

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	A. HIgh Ranchland Suitability		
1	Perennial Water - NHD, Washington Columbia Plateau	U.S. Geological Survey (NHD)	*https://wsuenergy.databasin.org/datasets/84a76ff1dcc74fd9bc6fac4c48808 9a1/*
2	Seeps and Springs NHD, Washington Columbia Plateau	U.S. Geological Survey	*https://databasin.org/datasets/876acc80d5864f73a08af06b0ef52050/*
3	Groundwater Wells GWIS, Washington Columbia Plateau	Washington State Department of Ecology	*https://wsuenergy.databasin.org/datasets/242d27981ebe492e85612302dd0a214e/*
4	Annual Precipitation 1991-2020 (PRISM), Washington Columbia Plateau	Oregon State University	*https://wsuenergy.databasin.org/datasets/bbec5c5f8c704311bc237f143cf31aef/*
5	gNATSGO - Available Water Storage, Washington Columbia Plateau	Natural Resources Conservation Service	*https://wsuenergy.databasin.org/datasets/b5224d68cf18421c9e1b12b4415ae777/*
6	gSSURGO - Depth to Soil Restrictive Layer, Washington Columbia Plateau	Natural Resources Conservation Service	*https://wsuenergy.databasin.org/datasets/451ecf0a449948ce9825c7cb7f631e57/*
7	Perennial Grass and Forbs RAP, Washington Columbia Plateau	USDA, NRCS, BLM, Univ. of Montana	*https://databasin.org/datasets/5e164a5fd445499a9576bb89f52c99f5/*
8	Bare Ground RAP, Washington Columbia Plateau	USDA, NRCS, BLM, Univ. of Montana	*https://databasin.org/datasets/c7d7a15558 0f495586dfe5784ee3159a/*
9	Annual Invasives RAP, Washington Columbia Plateau	USDA, NRCS, BLM, Univ. of Montana	*https://databasin.org/datasets/f7d57fa0c7854bd8b4d3f9ebe19c9990/*
10	Washington State Agricultural Land Use - 2021	Washington State Department of Agriculture	*https://wsuenergy.databasin.org/datasets/bc15bd69964749c0918c2d4d89335196/*

Table C-3. *Continued*

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	B. Federal Program Lands		
10	Washington State Agricultural Land Use - 2022	Washington State Department of Agriculture	*https://wsuenergy.databasin.org/datasets/074bb67ebb664059b5fb0bbf86c36b5c/*
11	Grazing Allotments with Animal Management Units, Oregon and Washington	Oregon Bureau of Land Management	*https://wsuenergy.databasin.org/datasets/96b5c35ea825447587c36f39ac177d4e/*
	C. Exclusions		
12	City Limits, Washington Columbia Plateau	Washington State Department of Labor and Industries	*https://wsuenergy.databasin.org/datasets/7eb016f6ec0642bc92449acf75683c4b/*
13	Perennial Water - NHD, Washington Columbia Plateau	U.S. Geological Survey (NHD)	*https://wsuenergy.databasin.org/datasets/84a76ff1dcc74fd9bc6fac4c488089a1/*
14	Protected Areas, Washington Columbia Plateau	Conservation Biology Institute	*https://wsuenergy.databasin.org/datasets/a0c87e943bd84d55a61c92b67509fb65/*

Table C-4. *List of Spatial Datasets used in the creation of the* ***Environmental Conservation Value Model*** *including reference numbers to the model diagram, dataset titles, sources, and links to the Data Basin Gateway.*

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	Connectivity Value		
1	Riparian Areas, Washington Columbia Plateau	U.S. Geological Survey	*https://wsuenergy.databasin.org/datasets/5480b150f34c4525b832c136dfaaaac6/*
2	Arid Lands Initiative (ALI) Cores and Linkages, Washington Columbia Plateau	U.S. Fish and Wildlife Services	*https://wsuenergy.databasin.org/datasets/e4eb06e525594f76818e9346acb79fe1/*
3	WDFW Cores and Linkages, Washington Columbia Plateau	Washington Department of Fish & Wildlif	*https://wsuenergy.databasin.org/datasets/c6d9032d99f4448da28b0663100eb483/*
	Natural Communities Value		
4	Rare Wetland and Riparian Communities (NHP), Washington Columbia Plateau	Washington State Department of Natural Resources	*https://wsuenergy.databasin.org/datasets/c413d2a42acf454185c6f11377df7636/*
5	Wetland Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/91fd421088084c3cb251b6f14cde5efb/*
6	Oak Habitat Priority Analysis - East Cascades Oak Partnership	Columbia Land Trust	*https://wsuenergy.databasin.org/datasets/5577245f05604520a4d25aff6c4c5f45/*
7	WDFW Ecosystems of Concern	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/171c2ff72d5a4e9999f55fe6cafoa512/*
8	Priority Habitats: Shrubsteppe General Locations, Washington	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/d59c570e9d08407ca38d048e12cd69ad/*
9	Rare Upland or High Quality Upland Communities (NHP), Washington Columbia Plateau	Washington State Department of Natural Resources	*https://wsuenergy.databasin.org/datasets/0395936odb374e089266ea8ce3197598/*
10	Aspen Stands, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/ecab9152bdc04185a792222a09b68a64/*
11	Inland Dunes, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/dcd6a8e0f0f347a4a844efc246935168/*
12	Talus Slopes, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/2e8b003cfbd34c03b0d1c0c028cfcfee/*

Table C-4. *Continued*

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	Natural Communities Value *(Continued)*		
13	Cliffs and Bluffs, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/641e7350afb648599f47a3de3c3c0380/*
14	Biome-wide Sagebrush Core Habitat and Growth Areas, 2020	Doherty et al. 2022	*https://wsuenergy.databasin.org/datasets/c3d69558c284414ba353d4a67b5bdf08/*
	Focal Species Value		
15	Endangered Vascular and Non-Vascular Plants (NHP), Washington Columbia Plateau	Washington State Department of Natural Resources	*https://wsuenergy.databasin.org/datasets/70e0743356114e678ce586ee624ed170/*
16	Threatened Vascular and Non-Vascular Plants (NHP), Washington Columbia Plateau	Washington State Department of Natural Resources	*https://wsuenergy.databasin.org/datasets/e432fb18f917490f9091340d012498a5/*
17	Sensitive Vascular and Non-Vascular Plants (NHP), Washington Columbia Plateau	Washington State Department of Natural Resources	*https://wsuenergy.databasin.org/datasets/68bffeee26e44c62b446cd1fdfeb9458/*
18	Columbia Spotted Frog General Occurrences, Washington	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/11e79190a6b44273aa7e734bc6daafa2/*
19	Sagebrush Lizard Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/7121506a6dbb4aacbd697286db4e749b/*
20	California Mountain Kingsnake Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/5e538158717b46c5bbe8fad16030355c/*
21	Striped Whipsnake Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/b9f2ef747e754d40ba02e2207d3009eb/*
22	Priority Amphibian and Reptile Conservation Areas (PARCA), Washington	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/1c9414566345408968db36d4fea82471/*

Table C-4. *Continued*

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	Focal Species Value *(Continued)*		
23	Northern Leopard Frog Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/c91d0d881fa643b88e274691951c0d7e/*
24	Western Pond Turtle Habitat Areas, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/8361f4fc07214121ac40b08d3e22c9e3/*
25	Sharptailed Snake General Occurrences, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/da79592e245b4be992b2fd9b52a6e8a0/*
26	Modeled Greater Sage Grouse Habitat, Washington	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/dc1adbd345e540fd8145cbe1fb6373f5/*
27	Columbian Sharp-tailed Grouse Habitat Concentration Areas, Washington	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/7ace725f8d5748e2b43a4b5827cb64d5/*
28	Ferruginous Hawk Generalized Occurrences, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/f7de91ff7f4044b683f33e24d98ecb92/*
29	Sandhill Crane Observations, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/ebbd2d2f7e084a9bb275d9db1a887d8d/*
30	Burrowing Owl Generalized Occurrences, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/b439ff43103742df9355842555c98a7a/*
31	Golden Eagle Generalized Occurrences, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/4e2688156d564db98eef727a67a9c571/*
32	Modeled Sagebrush Sparrow Habitat Suitability, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/d9ad74f430e44162802ba2ea285157e3/*

Table C-4. *Continued*

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	Focal Species Value *(Continued)*		
33	Loggerhead Shrike Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/2ffab3b0418b4c25bc7d61f0f25db6ff/*
34	Modeled Sage Thrasher Habitat Suitability,Wash-ington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/dcc729f4e87742bda6e74dbfc7a0a686/*
35	Waterfowl Concentration Priority Habitats, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/a2697cdee12742219b8231cf77a670e0/*
36	Brewer's Sparrow Modeled Suitability, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/e302118d60d24b8097b68b2e2d23ad86/*
37	Pygmy Rabbitt Habitat Suitability, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/9a39062413e2432a9621fa72f02ebf8c/*
38	General Cave Areas Important for Bat Species, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/68477ad20aa847ac8d72d59f2f5462bd/*
39	Western Grey Squirrel Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/9b7ca59d0c984f26ba58441d4686fd6a/*
40	Washington Ground Squirrel Habitat Concentration Areas, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/4057b7013b9947f59e6aea372b5c83b8/*
41	Townsends Ground Squirrel Habitat Concentration Areas, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/da89bc75d520465b8d9c9bf665febace/*
42	Black-tailed Jackrabbit Habitat Concentration Areas, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/50fc9c889a9148fca01587c92f35ec75/*

Table C-4. Continued

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	Focal Species Value *(Continued)*		
43	White-tailed Jackrabbit Habitat Concentration Areas, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/82f4404044fc446689d151e63698684d/*
44	Mule Deer Parturition Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/54b166994eda4ecb87f68a4df2516e71/*
45	Elk Parturtion Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/ecae114c05b54d54b39c372016729e1c/*
46	Rocky Mountain Elk Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/9026562ab5864e389d2052a699b3ca3/*
47	Elk Migration Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/39e9a93c21664196acede30431110338/*
48	Pronghorn Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/48d5498a7e934918989987e0c6e8e966/*
49	Mule Deer Winter Range, Washington	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/fd48090e4ebd41cb8bb3da03c5b33350/*
50	Mule Deer Migration Corridor, Washington	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/faae79853f4045e6ab3deff90304c541/*
51	Bighorn Sheep Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/acae6657166848fe97724a8ee5eba000/*
52	Mule Deer Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/b8a3bb58a1334c50a2c8542b7078f2e6/*
53	Elk Priority Habitat, Washington Columbia Plateau	Washington Department of Fish & Wildlife	*https://wsuenergy.databasin.org/datasets/bb7318f2b840414e81f31a880575f196/*

Table C-4. Continued

Model Reference	Dataset Title	Source	Data Basin Gateway Link
	Other Conservation Priorities		
54	TNC Northwest Plan Portfolios	The Nature Conservancy, Washington Chapter	*https://wsuenergy.databasin.org/datasets/bd1e482522b740aea70c871b87de517d/*
55	United States Important Bird Areas - National Audubon Society Authoritative Data	National Audubon Society	*https://wsuenergy.databasin.org/datasets/fdb91971a11d46d39661f0a56c3585ca/*
	Hign Conservation Value Comp w/ Pas		
56	Listed Species Composite, Washington Columbia Plateau	Conservation Biology Institute	*https://wsuenergy.databasin.org/datasets/87c69afa64e34042adba941e4856bac7/*
57	Protected Areas Database of the United States (PAD-US) 3.0 Washington	U.S. Geological Survey	*https://wsuenergy.databasin.org/datasets/33ee4572d2be497987005f90a55e9ac7/*
	Exclusions		
58	Conservation Reserve Program Lands (2022), Washington Columbia Plateau	Washington State Department of Agriculture	*https://wsuenergy.databasin.org/datasets/bfc48e59b94848b4adb1ad62e777be7b/*
59	National Land Cover (NLCD) 2019, Washington Columbia Plateau	U.S. Geological Survey	*https://wsuenergy.databasin.org/datasets/5b20dbdc66ff4e61b88d3616197ef003/*
60	Dryland Crops (2022), Washington Columbia Plateau	Washington State Department of Agriculture	*https://wsuenergy.databasin.org/datasets/29977dc8a67d42cf9af4f94af0752c7d/*
61	Irrigated Crops (2022), Washington Columbia Plateau	Washington State Department of Agriculture	*https://wsuenergy.databasin.org/datasets/0e7fa949f8a84673befa3839e409be78/*

Photo by Renee Hadley; courtesy of Washington State Conservation Commission

Appendix D
Maps of High-Level Panels from Tree-Based Models

The following figures show various panels (nodes) from the solar suitability, farmland, ranchland, and environmental conservation EEMS tree-based models.

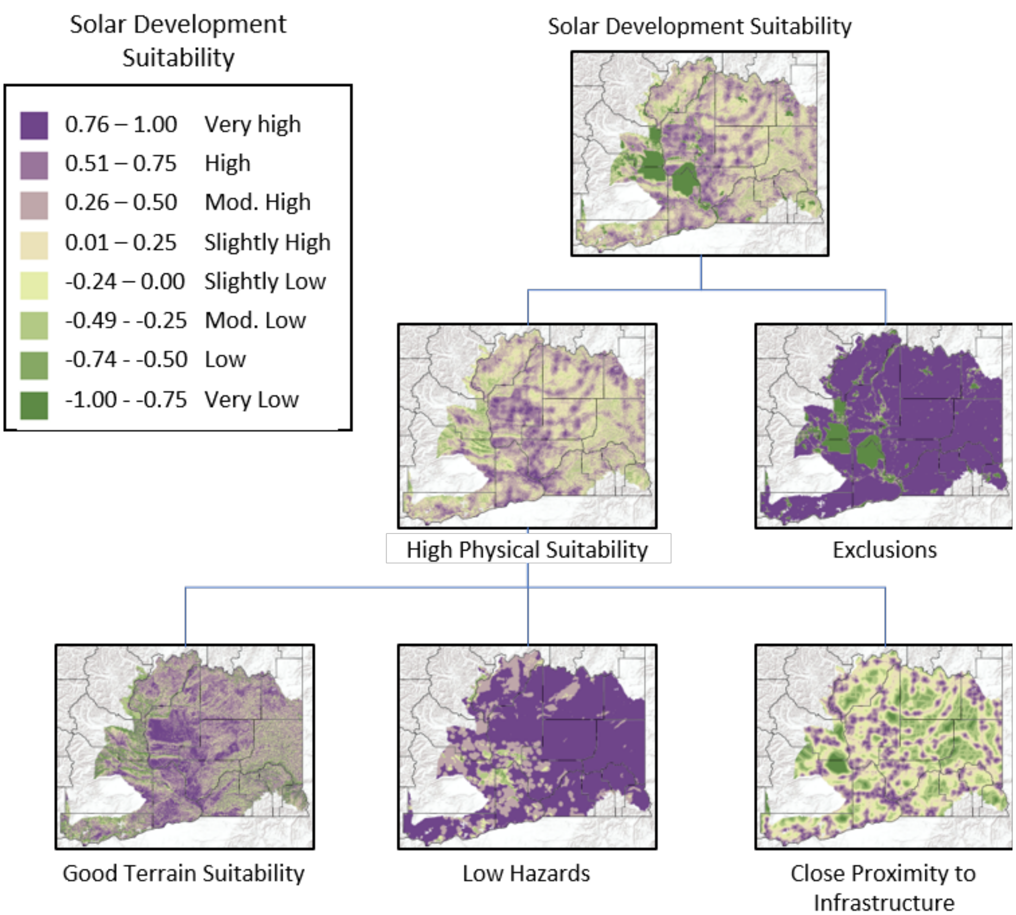


Figure D-1. *High-level map panels (nodes) for the Solar Development Suitability Model. These correspond to the high-level nodes in* ***Figure 5****.*

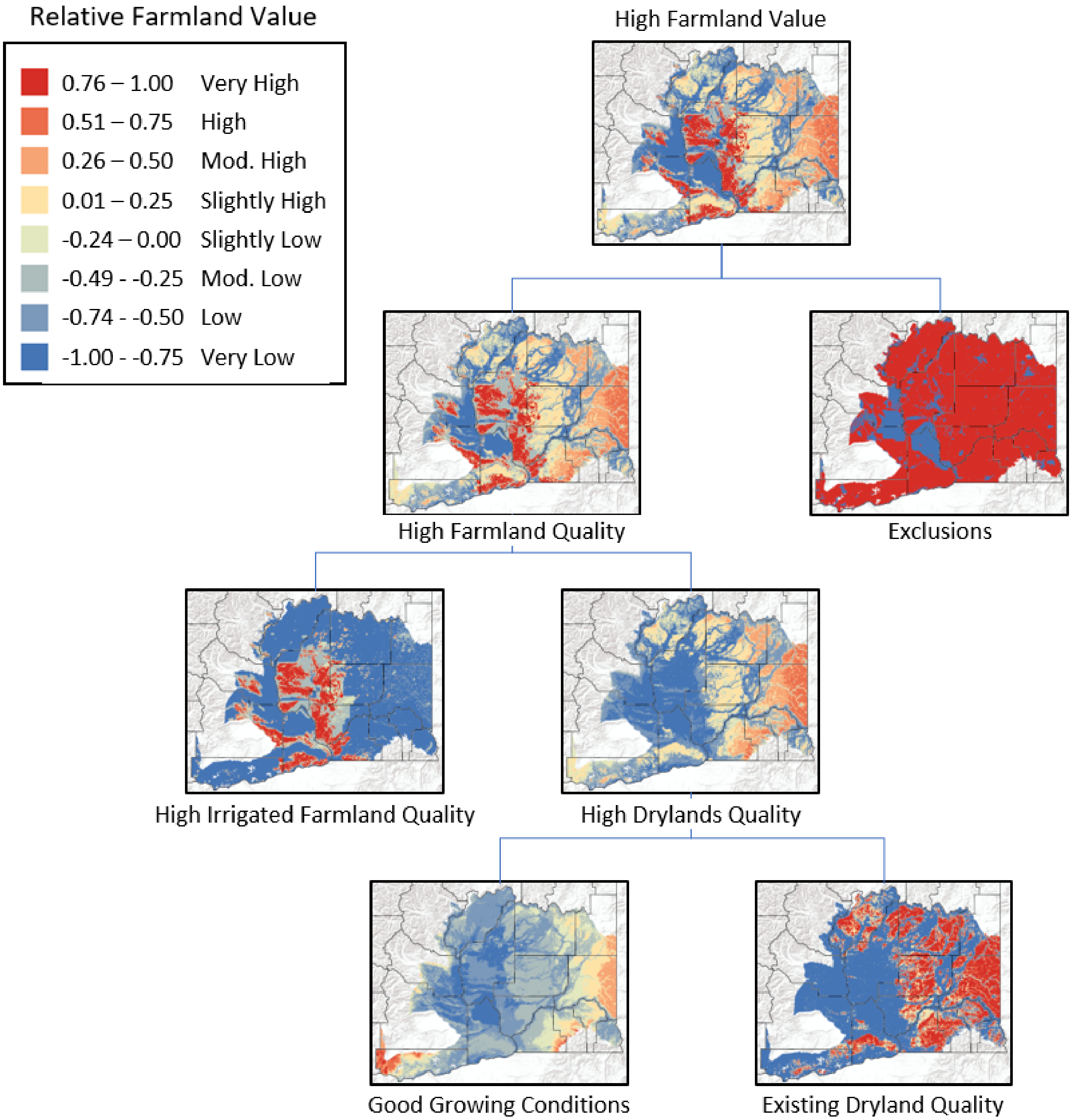


Figure D-2. *High-level map panels (nodes) for the Farmland Value Model.These correspond to the high-level nodes in* ***Figure 8****.*

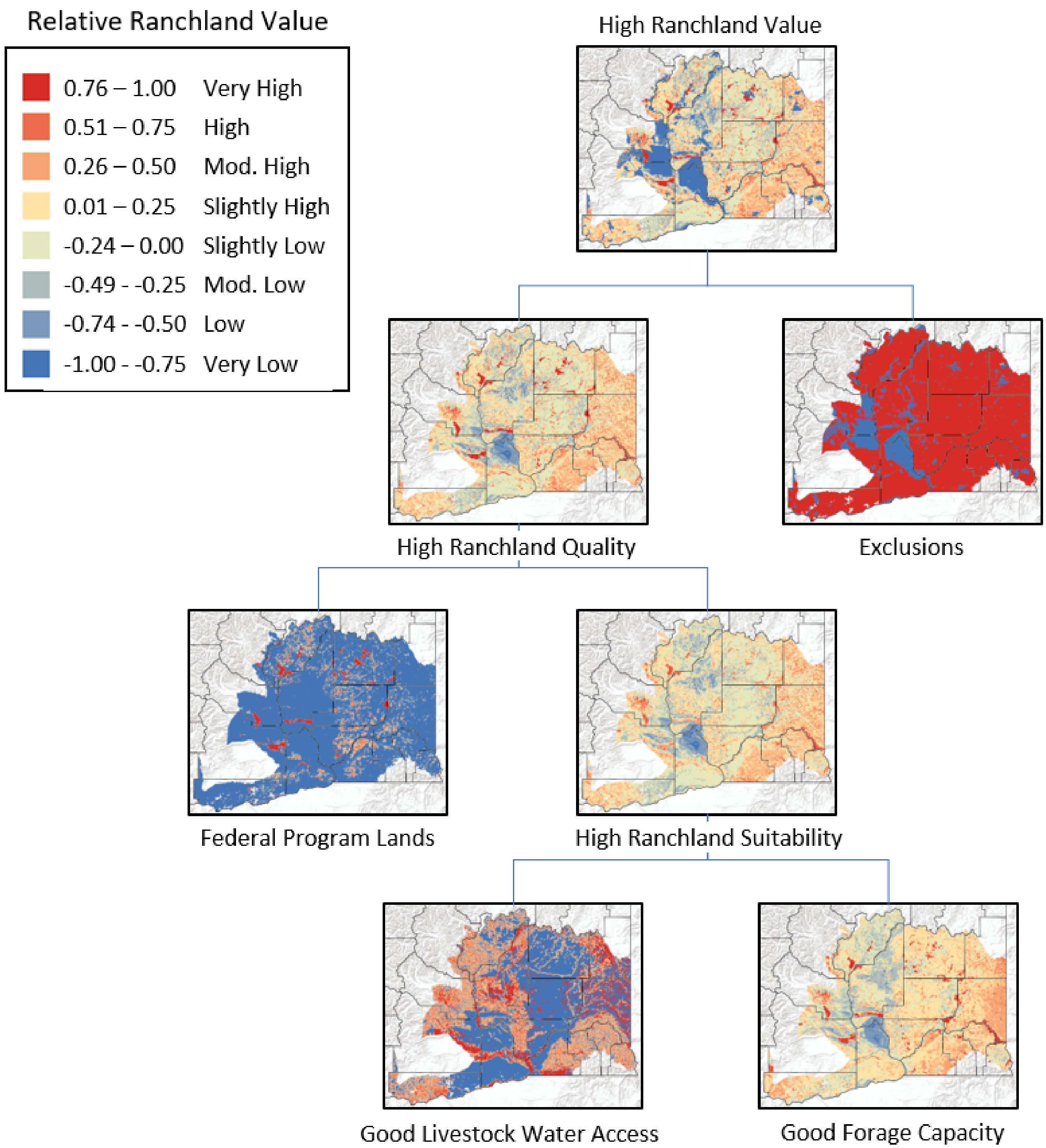


Figure D-3. *High-level map panels (nodes) for the Ranchland Value Model. These correspond to the high-level nodes in* ***Figure 11****.*

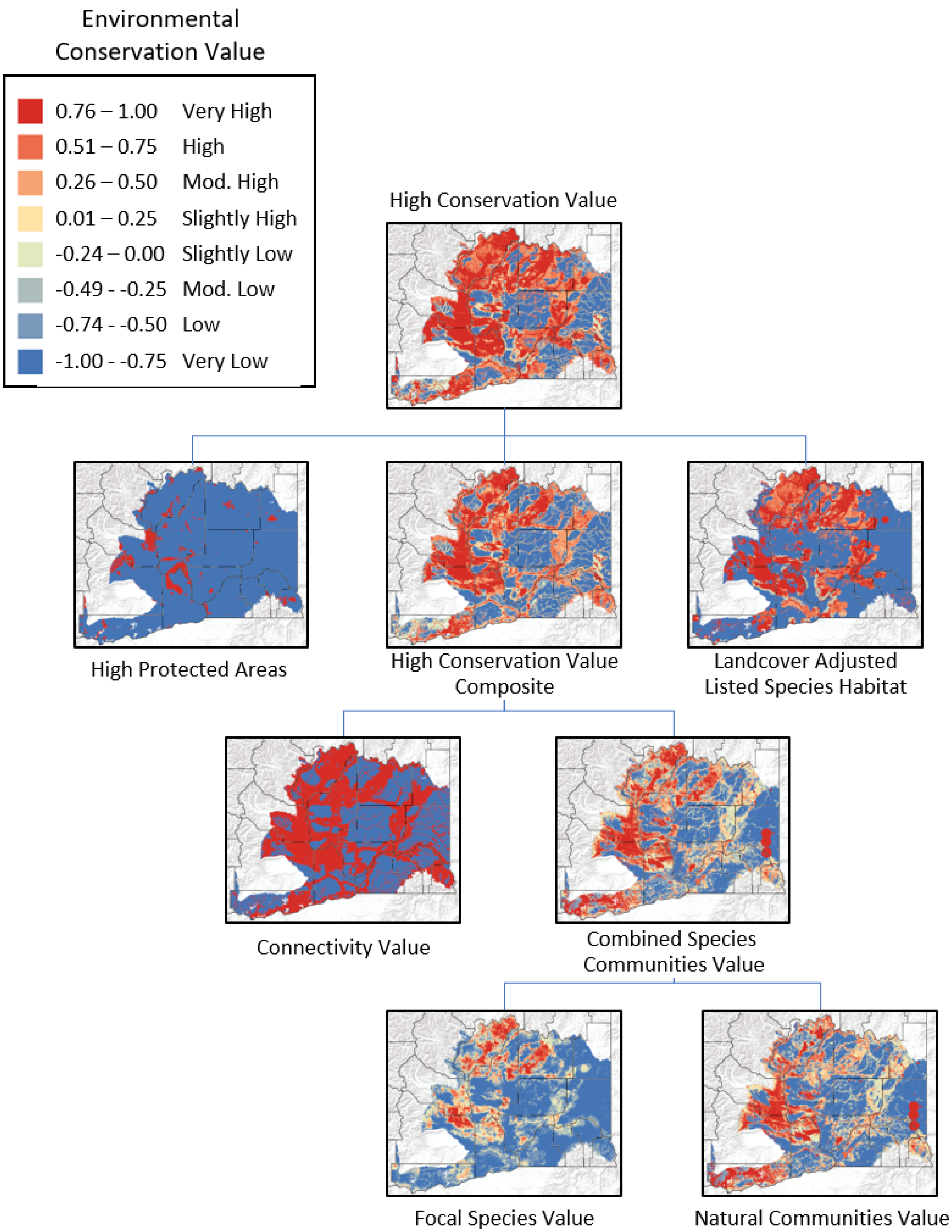


Figure D-4. *High-level map panels (nodes) for the Environmental Conservation Value Model. These correspond to the high-level nodes in* ***Figure 14****.*

Photo by Tom English; courtesy of Washington State Conservation Commission

Appendix E

Statement by the Confederated Tribes of the Colville Reservation

The traditional territories of the Confederated Tribes of the Colville Reservation extend across eastern Washington and into portions of British Columbia, Oregon and Idaho. This expanse covered approximately 39 million acres for our twelve constituent tribes (see **Figure E-1**). This does not include usual and accustomed areas outside our traditional territories. The twelve tribes consist of the sʔukʷnaʔqín (Lakes), sx̌ʷýʔłpx (Colville), sʔukʷnaʔqín (Okangan), škwáxčənəxʷ (Moses-Columbia), šnp̓əšqʷáw̓šəxʷ (Wenatchi), šntiyátkʷəxʷ (Entiat), ščəl’ámxəxʷ (Chelan), sp̓aƛ̓mul̓əxʷəxʷ (Methow), nspiləm (Nespelem), sńpʕawílx (Sanpoil), wal’wáma (Chief Joseph Band of Nez Perce) and palúspam (Palus tribes).

The Original Colville Indian Reservation was established by Presidential Executive Order April 9, 1872. In July of 1872, less than three months after the original Colville Reservation was established, it was exchanged for the present reservation, which was originally twice as large as the 1.4 million acres it is today. In 1879 the Moses or Columbia Reservation was set aside for the Chief Moses which included Columbia, Chelan, Entiat and Wenatchi tribes. In 1883 the Moses-Columbia Reservation returned to public domain and in 1884 Chief Moses made an agreement to move to the Colville Reservation. The short lived Wallowa Reservation was established for the Chief Joseph Band in 1873. In 1892 the north half of the Colville Reservation was ceded to the United States by an act of Congress (27 Stat. 62). There was also a promised reservation for the Wenatchi, but it was never established. See **Figure E-2** for former and current reservations. Note that Executive Order tribes never ceded any of their rights.

After the Colville Reservation was established it was managed by the Bureau of Indian Affairs with leaders of the individual tribes following traditional ways. By February of 1938 a Constitution was ratified for the Confederated Tribes of the Colville Reservation and a fourteen member Colville Business Council was elected from the Tribes’ four Districts. The current Colville reservation encompasses 1.4 million acres of land, consisting of tribally owned lands held in federal trust status for the Colville Confederated Tribes, land owned by individual Colville tribal members (most of which is also held in federal trust status), and land owned by other tribal or non-tribal entities. The Colville tribes also have thousands of acres of off reservation management areas. The Colville tribal membership is about 9,500 individuals. The Reservation's diverse landscape varies from forested mountains to riverine steppe sage grassland. The economy is fueled by tribal and federal government operations, timberlands, gaming, and numerous tribal enterprises. The area provides numerous opportunities for socioeconomic development. Lakes and streams offer outdoors-recreational pursuits for both the visitors and the residents of the Reservation. The Tribe intends to preserve the land and traditions of the Indian People. At the same time, self-sufficiency and sovereignty will be advocated as the Tribe utilizes the many resources available.

Given the vast traditional territory we occupied and the diverse nature of our landscape and economy, we have many interests in solar siting. We need to balance the energy needs of the State with our natural and cultural resource concerns. Our energy vision remains focused on hydropower but we continue to investigate alternative systems – wind, solar, and off-channel pump storage.

Figure E-1. *Colville Tribes Traditional Territories and Location of the Colville Reservation*

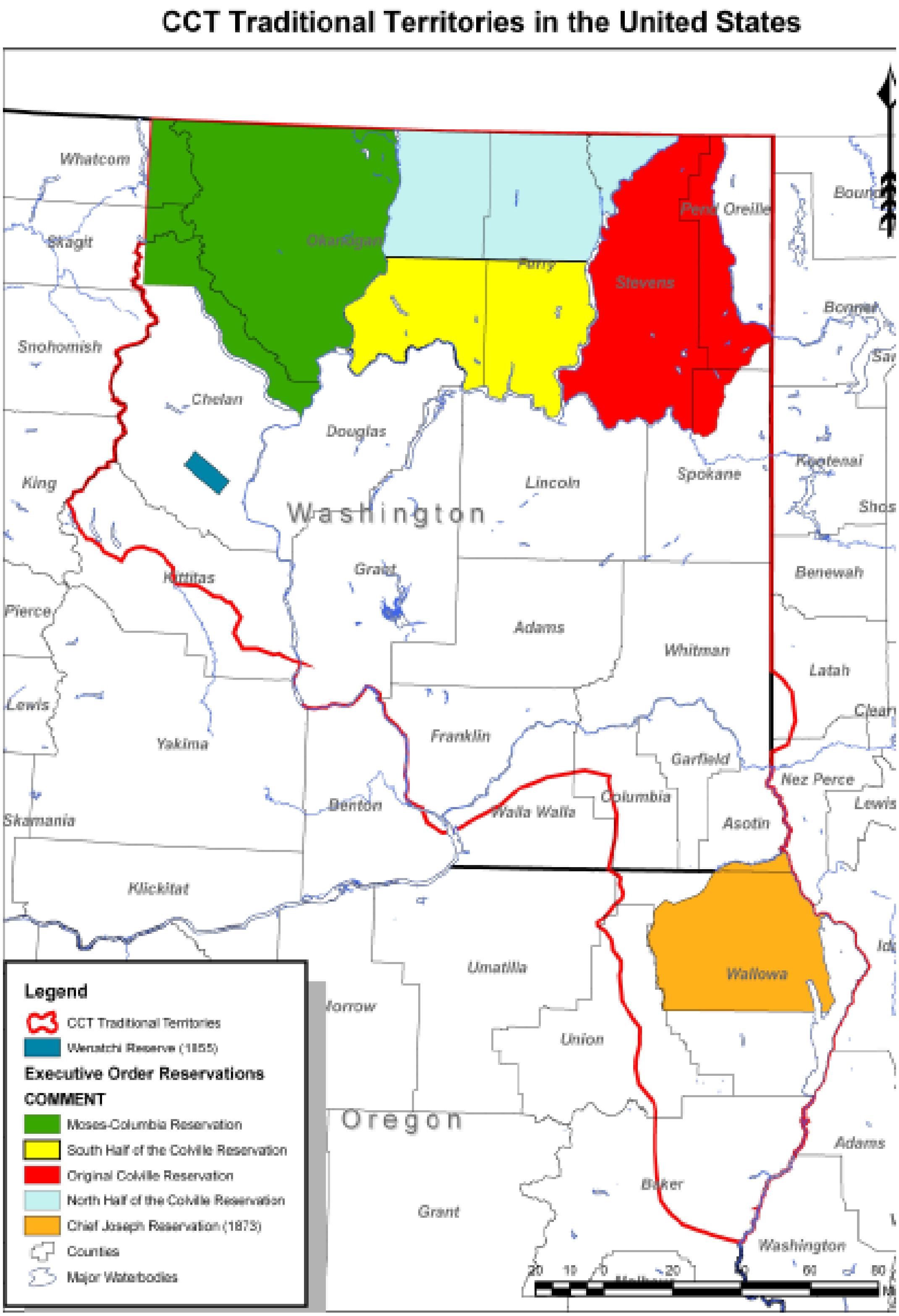


Figure E-2. *Current and Former Colville Reservations*

Photo by Grant Traynor; courtesy of Washington State Conservation Commission

Acronyms and Glossary

BLM .... U.S. Bureau of Land Management
BPA .... Bonneville Power Administration
CBI .... Conservation Biology institute
CETA .... Clean Energy Transformation Act
cm .... centimeter
CRITFC .... Columbia River Inter-Tribal Fish Commission
CRP .... Conservation Reserve Program
DNR .... Washington State Department of Natural Resources
EEMS .... Environmental Evaluation Modeling System
EFSEC .... Energy Facilities Site Evaluation Council
EIS .... Enviromental Impact Statement
GHG .... Greenhouse gas emissions
GMA .... Growth Management Act
GWIS............... Generalized Well Information System
HEAL Act......... Healthy Environment for All Act
HB................... house bill
m .... meter
M .... Million
mm .... millimeter
MW .... MegaWatt
NEPA............... National Environmental Policy Act
NHD .... National Hydrography Dataset
NHPA .... National Historic Preservation Act
PHS .... Priority Habitat and Species
PV .... photovoltaics
SB .... state bill
SEIA .... Solar Energy Industries Association
TNC................. The Nature Conservancy
TCWG .... Transmission Corridors Work Group
USDA .... U.S. Department of Agriculture
V .... Volt
VSP .... Voluntary Stewardship Program
WA .... Washington
WDFW .... Washington Department of Fish & Wildlife
WSU................ Washington State University

Glossary

Data Basin............... web-based mapping and collaboration platform

Fuzzy logic .... information along a true-false continuum (from true = +1.0 to false = -1.0) as opposed to a binary yes or no

GAP status .... measure of management intent to permanently protect biodiversity

Gateway.................. customized Data Basin platform focusing on a topic and/or geography, in this case Columbia Plateau Least-Conflict Solar Siting

Geospatial............... place-based or locational information/data with a geographic component