Staff Memorandum

To: Chair and Members of the Oregon Environmental Justice Council

From: Eric Main, Oregon Health Authority

Date: August 12, 2026

Regarding: Agenda Item 4: EJ Mapping Tool – Adopt Statewide & Community Designation Indices

The Oregon Environmental Justice Mapping Tool project has recently completed sensitivity analysis for the approved indicators for the Statewide, Coastal, Remote, Rural, Large City, and Small City indices based on the indicators approved for all indices during the May 6, 2026 and June 10, 2026 Oregon Environmental Justice Council (EJC) meetings. The community designations were approved by the EJC on April 11, 2024.

Staff will present additional support for indicator recommendations in the Statewide Index on June 10, 2026 and request the EJC to adopt the indicator recommendations for community designation indexes: Coastal, Remote, Rural, Small City, and Large City. The sensitivity analysis provides additional information about how indicators affect the composite EJ index. Most indicators recommended for the EJMT are regarded as a moral imperative while a small set add unnecessary redundancy. The Methodology Workgroup will present candidates that the EJC may consider dropping from the set of core EJ index indicators.

Staff recommendations per subdomain are listed below:

Environmental Exposures Subdomain – Statewide, Coastal, Remote, Rural, Small City, and Large City Index Indicators

1. *Air Quality Index (AQI) Unhealthy Days*
2. *Cancer Risk from Diesel Particulate Matter (PM)*
3. *Cancer Risk minus Diesel PM*
4. *Drinking Water Contaminants Index*
5. *Lead Exposure Risk Index*
6. *Permitted Air Pollution Sites*
7. *Transportation Noise Pollution*

Environmental Hazards Subdomain – Statewide, Coastal, Remote, Rural, and Large City Index Indicators

1. *Earthquake Risk*
2. *Groundwater Threats - Cleanup Sites, Leaking Underground Storage Tanks, Landfills, Confined Animal Feeding Operations*

3. *Hazardous Material Storage*
4. *Hazardous Waste Facilities*
5. *Impaired Water Bodies*
6. *Residential Buildings in Wildfire Burn Areas*
7. *Wastewater Discharge*

Environmental Hazards Subdomain – Small City Index Indicators

1. *Earthquake Risk*
2. *Groundwater Threats - Cleanup Sites, Leaking Underground Storage Tanks, Landfills, Confined Animal Feeding Operations*
3. *Hazardous Material Storage*
4. *Hazardous Waste Facilities*
5. *Impaired Water Bodies*
6. *Wastewater Discharge*

Environmental Hazards Subdomain – Small City Index Indicators Rationale:

Climate Change Risks Subdomain – Statewide, Remote, Rural, Large City, and Small City Index Indicators

1. *Days with Max Temperature above the 90th Percentile*
2. *Days Below 32F*
3. *Drought*
4. *Fire Weather Index Events*
5. *Flood Risk*
6. *Heat Index Days above 90F*
7. *Wildfire Risk*

Climate Change Risks Subdomain – Coastal Index Indicators

1. *Crab and Shellfish Harvest Closures*
2. *Days with Max Temperature above the 90th Percentile*
3. *Days Below 32F*
4. *Drought*
5. *Extreme Wind Events*
6. *Flood Risk*
7. *Wildfire Risk*

Built Environment Subdomain – Statewide, Coastal, Remote, Rural, Large City and Small City Index Indicators

1. *Access to Healthcare*
2. *Access to Parks*
3. *Community Design Index = Walkability + Population Density – Impervious Surface*
4. *Digital Equity – Access to Highspeed Internet*
5. *Food Insecurity – Access to Healthy Food + SNAP Recipients*
6. *Traffic Safety – Injuries and Fatalities*
7. *Urban Tree Canopy Coverage*

Human Health Subdomain – Statewide, Coastal, Remote, Rural, Small City, and Large City Index Indicators

1. *Adult Cancer Prevalence Minus Skin Cancer*
2. *Circulatory Disease Prevalence*
3. *Diabetes Prevalence*
4. *Frequent Mental Distress Prevalence*
5. *Population Living with a Disability*
6. *Preterm Birth Prevalence*
7. *Respiratory Disease Prevalence*

Demographic & Social Factors Subdomain – Statewide, Small City, and Large City Index Indicators

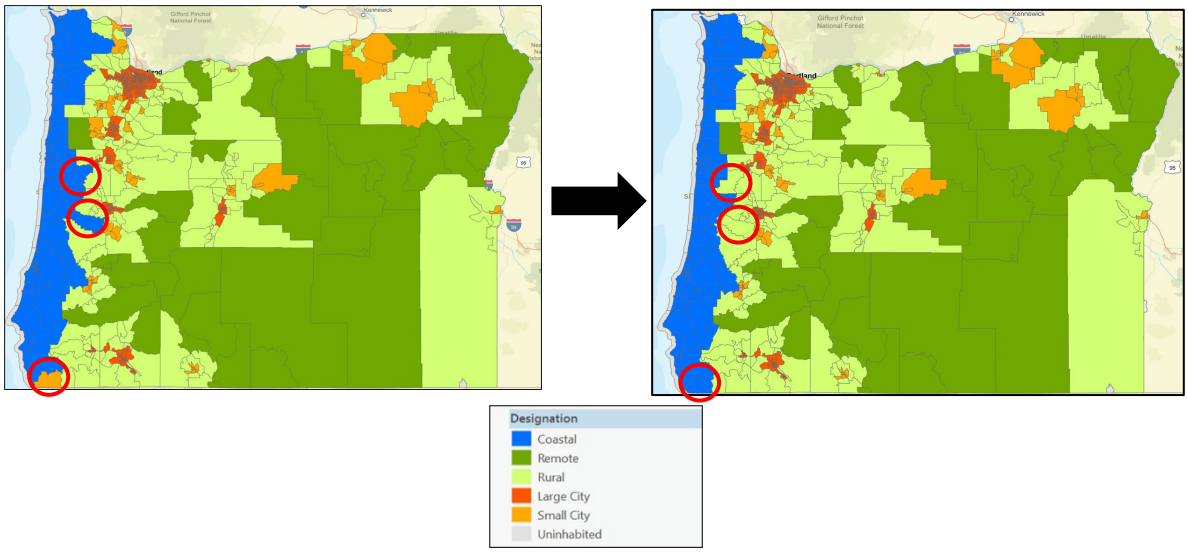
1. *65+ Living Alone (Social Isolation)*
2. *Adults Without a College Degree*
3. *Households without Access to a Vehicle*
4. *Inheritance Proxy (Generational Wealth)*
5. *Limited English Proficiency*
6. *Population Below 150% of the Federal Poverty Level*
7. *Population Under 5 Years Old*

Demographic & Social Factors Subdomain – Coastal, Rural, and Remote Index Indicators

1. *65+ Living Alone (Social Isolation)*
2. *Adults Without a College Degree*
3. *Employment Hardships*
4. *Households without Access to a Vehicle*
5. *Limited English Proficiency*
6. *Population Below 150% of the Federal Poverty Level*
7. *Population Under 5 Years Old*

Community Designation Revision

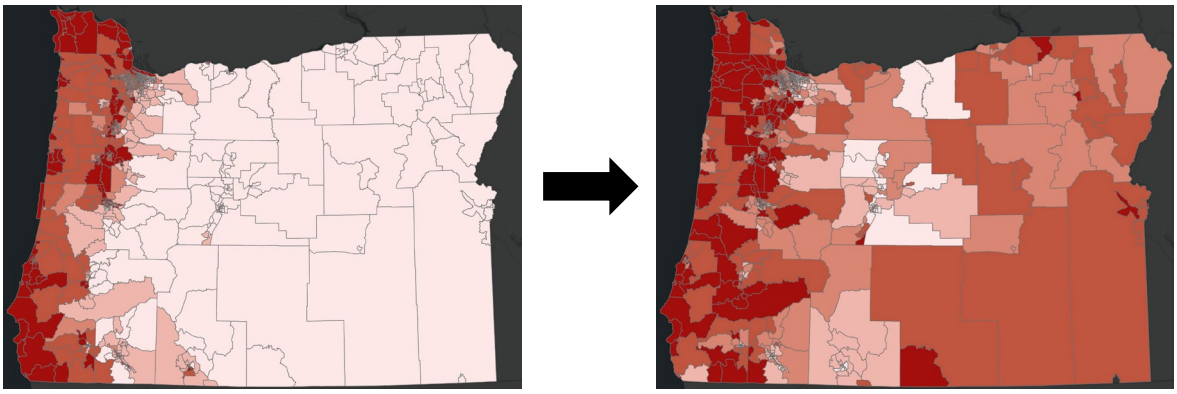
The Methodology WG discovered a relic in the method used to designate coastal communities that is inconsistent with the updated method used for community designations. Geometric centroids of census tracts intersecting DLCD's Coastal Zone were previously used to designate Coastal Communities. The preferred method uses a tract's population-weighted centroid. The revision affects three census tracts – two tracts were converted from Coastal to Rural and on tract was converted from Small City to Coastal.



Earthquake Risk Indicator Revision

The sensitivity analysis revealed that Earthquake Risk was the leading indicator in the environmental justice index meaning the indicator had the greatest influence on the model. The Methodology WG recognized that the underlying data, probability of damaging shaking, is not an inadequate measure of earthquake risk. Risk of shaking was replaced by the Earthquake Hazard used in DLCD's Natural Hazards Risk Assessment. The revised Earthquake Risk indicator now includes:

- Percentage of critical facilities
- Number of historic buildings
- Miles of major roadway exposed to Moderate to Very High liquefaction zones
- Area of tract in high or very high liquefaction hazard
- Number of bridges that are within high or very high liquefaction hazard
- Probability of Damaging Shaking



The Earthquake Risk indicator revision resulted in modest changes to Environmental Hazards indicator weights.

Environmental Exposures		Environmental Hazards		Climate Change Risks		Built Environment	
Air Quality Index Unhealthy Days	14.7%	Earthquake Risk	14.6%	Days Below 32°F	13.8%	Access to Healthcare	13.5%
Cancer Risk for Diesel Particulate Matter	14.1%	Groundwater Threats	14.6%	Days with Max Temp ≥ 90th Percentile	13.5%	Community Design Index	15.1%
Drinking Water Contaminants Index	16.2%	Hazardous Material Storage	13.2%	Drought	14.8%	Digital Equity / No Internet Access	15.2%
Transportation Noise Pollution	13.1%	Hazardous Waste Facilities	14.3%	Fire Weather Index Events	14.8%	Food Insecurity	14.7%
Lead Exposure Index	13.3%	Impaired Water Bodies	15.7%	Flood Risk	13.7%	Park Access	13.4%
Cancer Risk minus Diesel PM	14.2%	Residential Buildings in Wildfire Burn Areas	13.1%	Heat Index Days > 90°F	15.1%	Traffic Injuries & Fatalities	15.3%
Permitted Air Pollution Sites	14.4%	Wastewater Discharge	14.5%	Wildfire Risk	14.4%	Urban Tree Canopy	13.3%

Sensitivity Analysis of Statewide EJ Index

The results of the sensitivity analysis are intended to support the Oregon Environmental Justice Council's decision-making process for the EJ Mapping Tool in the following ways:

- Provide insight into how the approved indicators for the Statewide Index and community designation indices contribute to adopted subdomains:
  - Environmental exposures
  - Environmental hazards
  - Climate change risk
  - Built Environment
  - Human Health
  - Demographic & Social Factors

- Provide rationale into recommendations from the EJ Mapping Tool Methodology Workgroup regarding adoption of the Statewide, Coastal, Remote, Rural, Large City, and Small City Indices.

Indicator Correlations

The Methodology Workgroup built a pairwise correlation matrix to evaluate the relationships between all indicators in the EJ index. Strong correlations among indicators can cause statistical redundancy and implicit double-weighting. Too much collinearity means extra indicators add no new information. There are several indicators in the EJ Mapping Tool with correlations greater than 0.5 where at least 50% of the indicator is explained by another indicator.

- Populations earning below 150% of the federal poverty level - Frequent mental distress = **0.55**
- Adults without a college degree – Population living with a disability = **0.66**
- Average number of days below 32F - Days with Max Temp at or Above 90th Percentile = **0.62**
- Cancer Risk from diesel particulate matter & Hazardous material storage = **0.51**
- Cancer Risk from diesel particulate matter & Permitted air pollution sites = **0.61**
- Diabetes prevalence & Diseases of the circulatory system = **0.56**
- Diabetes prevalence & Diseases of the respiratory system = **0.78**
- Diseases of the circulatory system & Diseases of the respiratory system = **0.62**
- Frequent mental distress & Uninsured population = **0.58**
- Hazardous material storage & Permitted air pollution sites = **0.57**
- Population with a disability & Uninsured population = **0.50**

Averaging the indicators within each subdomain caps the maximum value of that subdomain and prevents a large cluster of correlated variables from mechanically inflating the domain scores.

Sensitivity Analysis Summary

Sensitivity analysis investigates the dependence of the composite index results on the indicator scores. Local sensitivity analysis was conducted to evaluate the contributions of indicators to the overall index score when small changes were made to each indicator one-at-a-time (OAT).

- **Flexible Modeling Environment (FME package) -** Perturbs indicator scores one-by-one by a small fraction (1%) and quantifies the differences in the composite index score.

Global sensitivity analysis was used to evaluate contributions of indicator scores when all indicator scores are changed and test the robustness of environmental justice index. Latin Hypercube Sampling and Monte Carlo Simulation were both used to test whether near-random sampling vs simulation would yield similar results. We used three models to conduct a thorough sensitivity anal analysis test structural uncertainty and guard against bias inherent in how the statistical models were built.

- **FME (FME package) -** Uses parameter sampling and model re-evaluation, relying on the partial rank correlation coefficient (PRCC) function that assesses how wide variations in indicator scores affect index outputs across all indicators, domains, and subdomains.
- **Sobol-Jansen (sensitivity package) -** Variance-based technique that estimates both first-order (S_i) and total-order (T_i) Sobol' indices simultaneously using a Monte Carlo formulation.
- **SHAP (shapr package) -** machine learning model that shows the exact average contribution of each individual indicator to the overall environmental justice index score, splitting up shared effects even when the inputs are correlated or the system is non-linear.

Local Sensitivity Analysis Results

Across all six subdomains, the composite index is most sensitive to variations in a small subset of indicators. A 1% shift in their weights produces the largest percentage change and range in the overall score. Indicators with the highest elasticities by subdomain:

- Adults Without College Degree (Social Factors)
- Access to Parks (Built Environment)
- Drought (Climate Change Risk)
- Distance to Healthcare (Built Environment)
- Limited English Proficiency (Social Factors)

Increasing weights for factors like Adults Without College Degree, Access to Parks, Drought, and Earthquake Risk directly increases the composite index value. Factors like Distance to Healthcare, Diseases of the Circulatory System, Wildfire Risk, and Limited English Proficiency move inversely meaning an increase in weight shifts the index value downward.

The People domain has slightly more influence on the EJ index score (38.8) than the Place domain (32.2) or 54.6% to 45.4%.

Global Sensitivity Analysis Results

FME

FME shows which indicators have the greatest influence on the EJ index score when all other indicator scores are varied. Indicators with strong positive correlations directly push the composite index higher:

- Adults Without College Degree (Social Factors)
- Access to Parks and Urban Tree Canopy (Built Environment)
- Drought (Climate Change Risk)
- Earthquake Risk (Environmental Hazards)

Several indicators exhibit negative PRCC values meaning there is an inverse relationship between the indicator and the EJ index score after controlling for the effects of all other parameters. All of the negative PRCC values are below -0.4 indicating that increasing the indicator score slightly decreases the EJ index score, but the effect is moderately weak to very weak.

- Limited English Proficiency PRCC = -0.37 (Social Factors)
- Diseases of the Circulatory System PRCC = -0.34 (Human Health)
- Distance to Healthcare PRCC = -0.33 (Built Environment)
- Wildfire Risk PCCC = -0.28 (Climate Change Risk)

Sobol-Jansen

Sobol-Jansen global sensitivity analysis measures the share of total output variance caused by indicator X_i, including interactions with other indicators. The method tells us which indicators have the most influence on the EJ index by revealing whether the indicators act independently or rely on complex interactions with other indicators. If an indicator has a Total Effect near zero ($T_i \approx 0$), it means that indicator barely affects the output and can safely be fixed to a constant without changing the model's behavior.

- Highest Total-Order Sensitivity (T): Adults Without College Degree under *Social Factors* has by far the highest total-order Sobol' index followed by Limited English Proficiency and Access to Parks (*Built Environment*).
- Strongest Direct Drivers (S): Adults Without College Degree is also the only factor with a significantly positive First-Order (S) Sobol' index. This means it directly drives a substantial share of the composite-index variance on its own, without relying heavily on interactions with other variables.
- Interaction effects drive most subdomains. Across almost all subdomains, First-Order indices (S) are negative or near zero while Total-Order indices (T) are positive.

- The individual variables rarely drive the variance in the composite index in isolation. Instead, their impact is almost entirely driven by higher-order interaction effects with other parameters in the model.
- Variables under *Environmental Exposures* (such as Cancer Risk, Lead Exposure, AQI Unhealthy Days, and Drinking Water Contaminant Index) show virtually zero Total-Order variance contribution ($T \approx 0$). This indicates that varying the weights of Environmental Exposures within the tested range ($\pm 50\%$ of PCA baseline) has negligible impact on the overall composite index score relative to socioeconomic and built environment factors.

Shapley

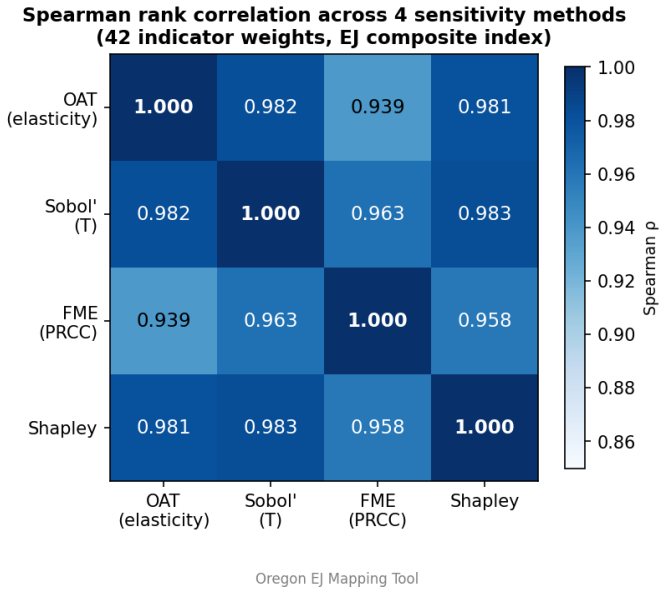
Shapley or SHAP is a machine learning model that shows the exact average contribution of each individual indicator to the overall environmental justice index score, fairly splitting up shared effects even when the inputs are correlated or the system is non-linear.

The EJ index relies most heavily on demographic/socioeconomic vulnerabilities and accessibility indicators (parks/healthcare), alongside large-scale natural disaster risks (drought, wildfires, earthquakes). Direct environmental exposure indicators (like air quality days or lead exposure) have comparatively minimal global impact on determining overall EJ scores in this baseline model configuration. Each subdomain has a clear lead indicator that carries most of its predictive/explanatory weight:

- **Social Factors:** Led by Adults Without College Degree (99.46) and Limited English Proficiency (46.15).
- **Built Environment:** Led by Access to Parks (69.91) and Distance to Healthcare (51.93).
- **Climate Change Risks:** Led heavily by Drought (68.65) and Wildfire Risk (40.66).
- **Environmental Hazards:** Led by Earthquake Risk (44.07).
- **Human Health**: Led by Diseases of the Circulatory System (42.43).
- **Environmental Exposures:** Substantially lower global importance overall, though Cancer Risk minus DPM leads at 13.35.

Sensitivity Analysis Conclusions

All four methods agree with each other at Spearman $\rho \geq 0.94$, and three of the four pairs are ≥ 0.98. This is a strong robustness signal.



PRCC is the consistent outlier, correlating a bit lower with the other three (0.94–0.96 vs. their mutual 0.98+). That tracks with what the FME script itself flags. PRCC assumes a monotonic relationship, and the composite's power-mean/product structure isn't strictly monotonic everywhere. This isn't a red flag on its own, just the expected fingerprint of that assumption.

Top 3 indicators are unanimous across all four methods: Adults Without College Degree, Access to Parks, Drought has the same rank across all methods. That is as strong a robustness statement as this kind of analysis can provide.

Biggest disagreement: "Annual Average Number of 3-Day Fire Weather Index Events" spans rank 22 (OAT) to rank 33 (PRCC) — an 11-rank spread. A handful of others (150% Poverty Rate, Digital Equity, Uninsured Population) show 7–10 rank spreads. The rank of these indicators should not be over-interpreted because they are not top-tier or bottom-tier by any method, just imprecisely located in the middle by all four.

Latin Hypercube vs Monte Carlo Simulation: Sensitivity analysis results were consistent using both methods.

Indicator Recommendations

The Methodology Workgroup recommends dropping Proximity to Permitted Air Pollution Sites for all indexes and Average Number of Days Below 32F for all indexes except the Coastal Community index.

Rationale

Proximity to Permitted Air Pollution Sites

Proximity to Permitted Air Pollution Sites is highly correlated with two indicators: Cancer Risk from Diesel Particulate Matter and Proximity to Hazardous Material Storage meaning

the indicator spatial trends convey similar information in the EJ index. The similarities are largely due to urban concentrations in many of the same areas. DEQ staff support the recommendation to drop the indicator but request including it as a decision support layer.

Average Number of Days Below 32F

Average Number of Days Below 32F is highly correlated with Days with Max Temp at or Above 90th Percentile (r^2 = 0.62). The indicator may also be interpreted as a false flag as counties in the Willamette Valley (Multnomah, Washinton, Clackamas, and Marion) tend to have the highest rates of cold-related deaths compared to other counties in Oregon that regularly experience greater averages of days with temperatures below 32F.

The Methodology Workgroup does not recommend dropping Average Number of Days Below 32F for the Coastal index because community members at the Astoria listening session communicated that frost is a major concern on the coast making travel by all modes of transportation dangerous. When average number of days below 32F are compared between coastal communities, it is a good measure for which communities experience hazardous travel most frequently.

Sensitivity Analysis Support

Dropping the two indicators slightly improves the influence of the Place domain: 45.3% to 45.9%.

Local Sensitivity Analysis

By dropping the two indicators, the EJ index baseline score went up, and the remaining indicators now have a bigger impact whenever their scores are adjusted.

- **Social Factors:** Remains by far the most sensitive subdomain to weight perturbations.
    - Adults Without College Degree displays the largest sensitivity band in both runs, but its range widens noticeably in the second run.
    - Limited English Proficiency also maintains a very wide band, showing high responsiveness to changes in weight.
- **Built Environment:** Continues to be the second most sensitive subdomain. Access to Parks, Distance to Healthcare, and Traffic Injuries and Fatalities show expanded response ranges in the second run.
- **Climate Change Risk:** Drought maintains the most sensitive within this subdomain, and its range expands further in the second run.
- **Environmental Exposures & Hazards:** Remain relatively insensitive to ±1% weight perturbations, indicating that small weight adjustments in these subdomains have minimal local impact on the overall index value.

Global Sensitivity Analysis

The most influential indicators (Adults Without College Degree, Drought, Access to Parks, Earthquake Risk, and Diseases of the Circulatory System) maintained almost identical PRCC values and rankings across both runs, showing that overall global parameter sensitivity remains highly robust for the main drivers.

Dropping the two indicators caused local re-rankings within weaker subdomains (particularly Environmental Exposures and Human Health) but did not alter the core non-linear behavior of the tool. The composite index remains heavily nonlinear and continues to be dominated by the exact same top drivers in Social Factors and Climate Change Risk. Dropping the indicators also simplified the overall model dynamics. The composite index became far more additive, meaning individual indicator variations now act more independently with much less indicator-to-indicator interaction.

Removing the two indicators reduced the overall sensitivity in Environmental Exposures and reordered the minor indicators within it.