Example Analyses using the DRCOG Equity Index

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DRCOG equity index background

DRCOG staff have developed an index of equity and marginalization data to better understand the geographic distribution of marginalized communities in the Denver region. The index is available for use by local jurisdictions or the public. The equity index dataset can be downloaded from the Regional Data Catalog in multiple formats, or for ease of use, can be accessed as a layer in the DRCOG Data Tool. Additional information on the technical construction of the index is available on the index data guide.

DRCOG suggested analyses

DRCOG suggests the following analysis methodologies for local agencies due to their ease of use and data integrity. Corridor analyses can be run for a specific project (for instance for a federal discretionary grant application). Portfolio analyses can be run for use on groups of projects (for instance in capital improvement programs, comprehensive plans, transportation master plans, or other investment analyses).

Corridor analysis

Select Census Tracts within 0.5 miles of a corridor (note that while corridors are likely the most common, points such as intersections or areas such as a microtransit service area can also be analyzed). Visualize the equity information using DRCOG's equity quartiles.

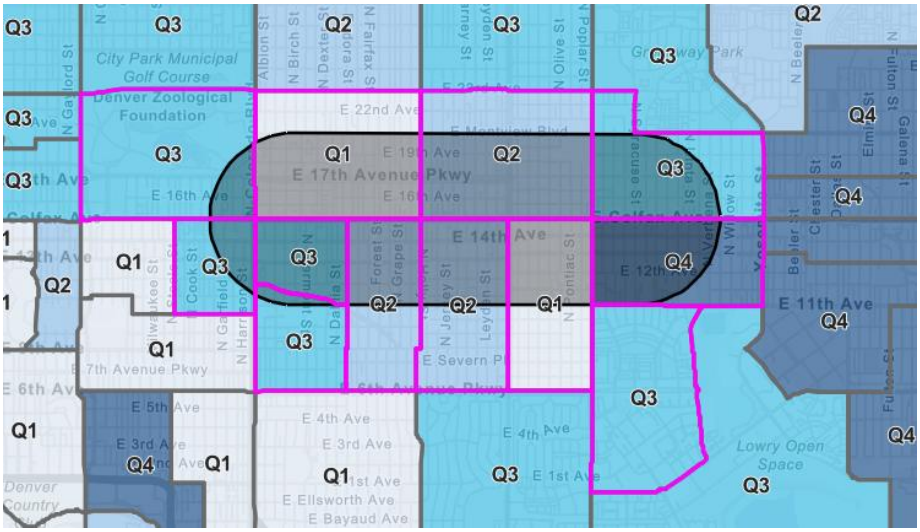
Using GIS software

1. Open the equity index dataset and shapefiles of your project locations in GIS.
2. Run a Buffer analysis tool with a distance of 0.5 miles. Set the tool to dissolve all output features into a single feature.
3. Use Select by location to identify the tracts that intersect with the buffer. Export the attribute table for the selected tracts to CSV.
4. Refer to the Qindex column for the equity quartiles.

Using the DRCOG Data Tool

1. On the Data tab, either upload a shapefile or use the point, line, or polygon icons to manually draw the project on the map.
2. Use the default 0.5 mile buffer.
3. The Data Tool will highlight the tracts which intersect with the buffer, which are already symbolized by quartile. In Figure 1, a project has been drawn in the Data Tool. The tool has applied a 0.5 mile buffer (shaded darker and outlined in black) and selected all tracts (outlined in purple) which intersect with the buffer.
4. Tracts are categorized in the Data Tool by quartile.

Figure 1. Example project in DRCOG Data Tool



Interpreting results

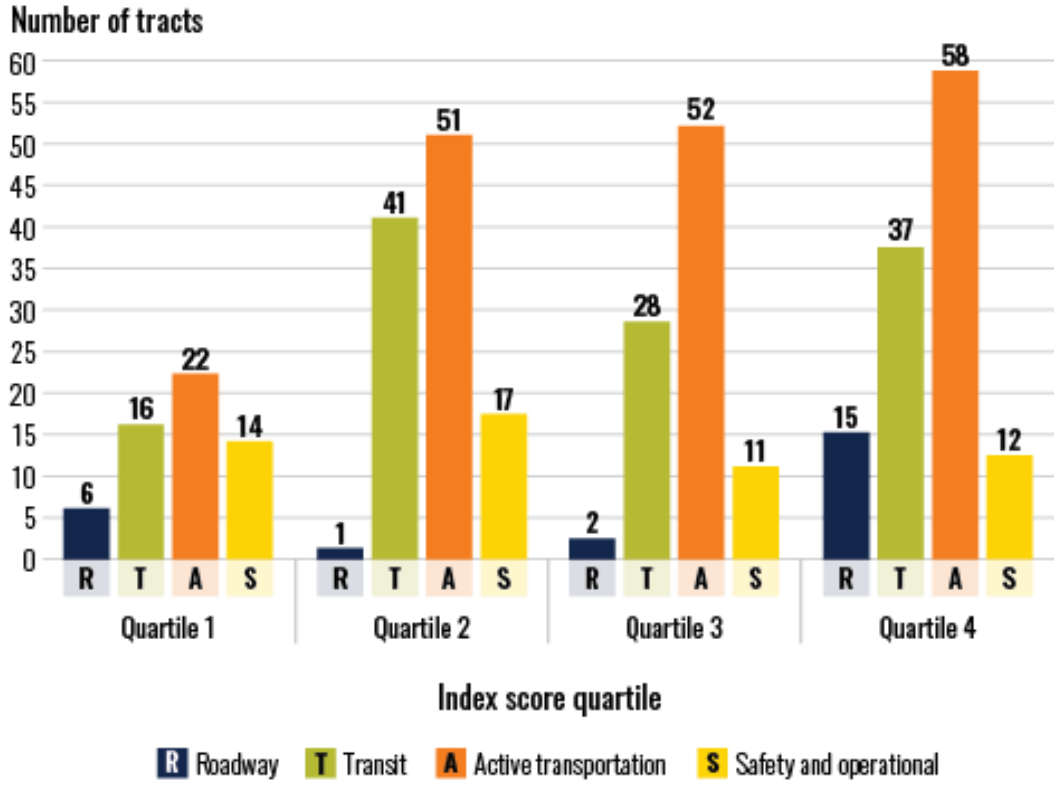
Quartile 1 represents the 25% of DRCOG census tracts with the least marginalization, and Quartile 4 represents the 25% with the most.

Using the example project in Figure 1, the level of marginalization differs quite a bit along this corridor, with tracts represented in all four quartiles. Given that the southeastern end of the project intersects with a Quartile 4 tract, this project is located adjacent to a tract with some of the highest concentrations of marginalization in the Denver region. This approach allows users to focus their attention on the portions of their projects which are located in the areas of the greatest marginalization. Great attention should be given to the potential burdens of a project in a Quartile 4 tract.

Portfolio of projects analysis

If evaluating a package of projects, consider the number of projects within very marginalized communities verses less marginalized communities. An example of this from the DRCOG Transportation Improvement Program is given in Figure 2. If projects are concentrated in tracts of a particular quartile, consider what that may mean for the investment package (for example, if projects are primarily in tracts in Quartile 1, might this represent underinvestment in more marginalized communities? If projects are primarily in tracts in Quartile 4, are those projects of a type primarily oriented toward the needs of residents in those communities, or might they represent a burden on them?). All agencies should take care to ensure benefits and burdens of infrastructure projects are distributed equitably for all communities (refer to the Benefits and burdens section for further discussion on this topic).

Figure 2. Transportation Improvement Program portfolio analysis



To perform this analysis for local projects, first determine if it is of interest to compare projects to the region as a whole, or to a smaller local geography. If projects are being compared to regional data, use the default quartiles and skip to the "Analyze projects" instructions. Otherwise, to perform this analysis for a local geography, such as a county, municipality or neighborhood, perform the following steps in the "Determine quartiles for the area of interest" section.

Determine quartiles for the area of interest

Using GIS Software

1. Open the equity index dataset and a shapefile of your area of interest (for example your county boundary).
2. Use Select by location.
    a. Use the equity index tracts as the input feature.
    b. Use the boundary shapefile as the selecting feature.
    c. Select Contains as the relationship.
3. Export the attribute table of the selected tracts to CSV. Continue with Step 4 ("Categorize tracts").

Using the DRCOG Data Tool

1. On the Data tab of the DRCOG Data Tool, upload a shapefile of the area of interest or use the polygon icon to manually draw the area on the map. Note that a shapefile will have significantly greater accuracy.

2. Set the buffer to zero.
3. The Data Tool will highlight all of the tracts which touch your area of interest. Export the data to CSV, which will provide a spreadsheet of the individual tracts highlighted by the Data Tool. Continue with Step 4 (“Categorize tracts”).

Categorize tracts

4. Because this subset of tracts will be different from the region, quartiles will need to be re-run (the Qindex column is based on regional data). Use Excel’s QUARTILE.INC function on the indexscore column to determine the quartile cutoff values for this subset of tracts. This function will provide the maximum value in each quartile.
5. Tracts will then need to be organized by quartile depending on which range they fall in. For example, if the QUARTILE.INC function returns 15.1 for the first quartile and 20.2 for the second, then anything between the minimum value and 15.1 would be a Q1 and 15.2 to 20.2 would be Q2, etc. Categorizing tracts can be accomplished using Excel’s IF function.
6. Once they are categorized, project sponsors can then run an analysis to determine the subset of tracts adjacent to their projects.

Analyze projects

Using GIS software

1. Open the equity index dataset and shapefiles of your project locations in GIS.
2. Run the Buffer analysis tool with a distance of 0.5 miles. Set the tool to dissolve all output features into a single feature.
3. Use Select by location.
    a. Use the equity index tracts as the input feature.
    b. Use the buffer as the selecting feature.
    c. Select Intersect as the relationship.
4. Export the attribute table for the selected tracts to CSV.

Using the DRCOG Data Tool

1. On the Data tab of the DRCOG Data Tool, either upload a shapefile or use the point, line, or polygon icons to manually draw the projects on the map.
2. Use the default 0.5 mile buffer.
3. The Data Tool will highlight all of the tracts which are impacted by the group of projects.
4. Export the data to CSV, which will provide a spreadsheet of the individual tracts highlighted by the Data Tool.

Interpreting results

If comparing projects to regional data, refer to the Qindex column. Otherwise, an additional step will be needed to join the table from the “Determine quartiles for the area of interest” section with the table from the “Analyze projects” section. Use the Tract ID and the VLOOKUP function to pull in the new quartiles into the project spreadsheet.

Quartile 1 represents the 25% of census tracts with the least marginalization, and Quartile 4 represents the 25% with the most.

A more granular approach would be to analyze the type of investment, such as by project type. In Figure 2, the DRCOG Transportation Improvement Program categorizes projects into four general project types. At the local level, it may be useful to use additional categories to get a more detailed picture. The analysis in the previous paragraph could then be repeated for each subset of projects to get the tracts by project type. This comparison can be helpful to see if investments in particular project types align with the demographics of neighboring communities. This can be especially helpful when tied to domains (refer to Domains section). For example, if an area has high mobility burdens (such as households without a car), are active transportation and transit investments being made to meet the needs of those residents?

Domains

In addition to the full Equity Index score, projects can also be evaluated under each of the three domain scores. The Index includes domains for Economic Status, Mobility Barriers, and Race and Ethnicity, with each representing a collection of related indicators. A higher score in a particular domain represents a higher level of marginalization. For instance, a tract with a high Economic Status score will have a high concentration of groups that may find the cost of transportation particularly challenging: low-income residents, households experiencing housing cost burdens, and single-parent households. For more information on the domains, reference the data guide.

The other analyses in this document are based on the overall equity index score, but can also be performed using each individual domain if a particular demographic trait is of interest. To do so, download the equity index dataset, and use the econscore column for the Economic Status Domain, mobscore for the Mobility Barriers Domain, and rnscore for the Race and Ethnicity Domain. If using a particular subregion, follow the steps in the “Determine quartiles for the area of interest” section to determine quartiles by domain using the relevant domain column in the dataset.

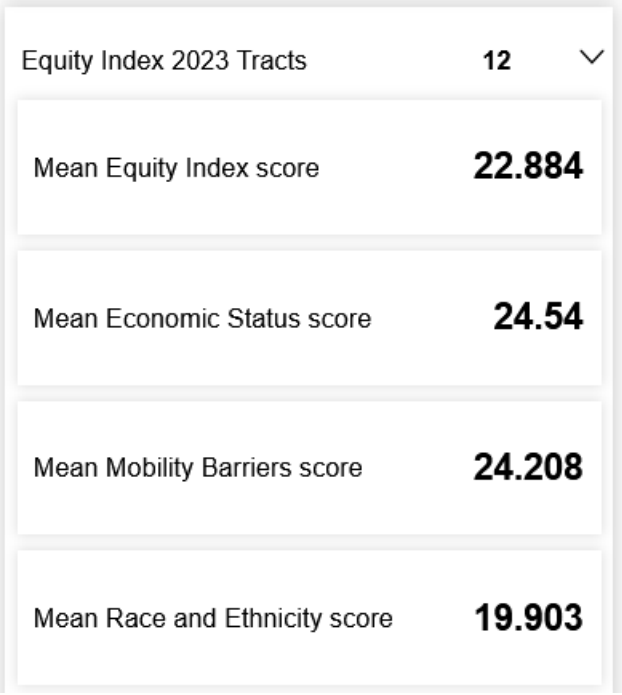
Additional analysis options

Comparison to a regional average

A project's index score can also be compared to the regional average (mean) index score. The regional average can be determined by downloading the full dataset as a CSV and taking the average of the indexscore column. As an alternative, at the local scale, a project could also be compared to a county average, municipal average, etc, with the understanding that census tracts will not always conform to municipal boundaries. As an example, to determine the average at the county level, download the dataset as a shapefile. Use a shapefile of the county boundary to select those tracts that intersect with the county polygon. Take an average of the indexscore column of the resultant tract records.

To determine a project score, on the Data tab of the DRCOG Data Tool, either upload a shapefile or use the point, line, or polygon icons to manually draw the projects on the map. Use the default 0.5 mile buffer. The Data Tool will provide the mean equity index score of all tracts which intersect with the buffer, as well as the mean score of these tracts within each of the three domains. For the example project shown in Figure 1, the Data Tool outputs are represented in Figure 3. As an alternative to the Data Tool, manually perform the same buffer function in GIS using a shapefile of the equity index dataset and take the average of the indexscore attribute of the resultant tracts.

Figure 3. Index scores of the example project in Figure 1

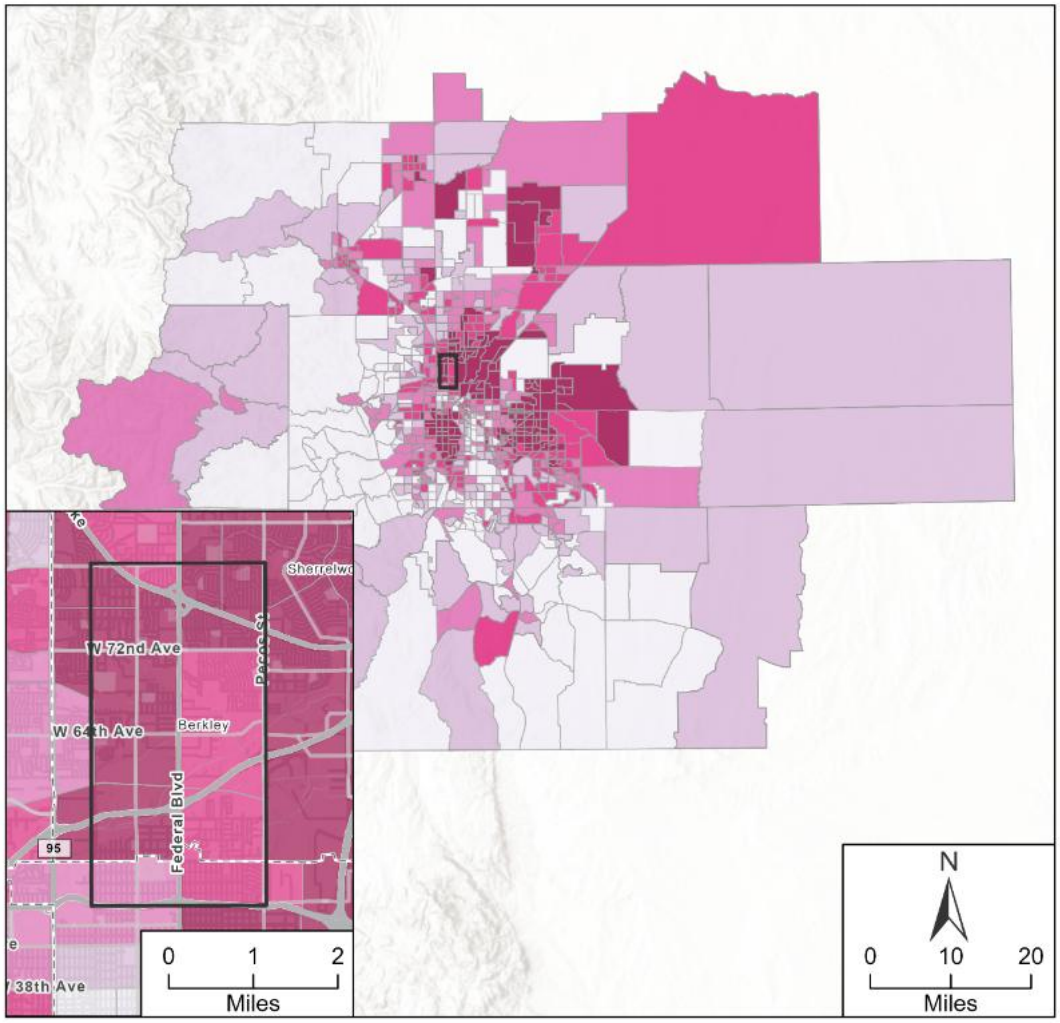


To determine how the project score relates to the regional (county, municipal, etc.) mean, use standard deviation. Standard deviation provides a statistically valid way to measure magnitude of variation from the mean. To calculate the standard deviation above or below the mean, use Excel's STDEV.S function, which will provide the cutoff value one standard deviation from the mean. Compare tract values to this cutoff value to determine how far they are from the regional mean (for example, if the regional mean is 20, and the standard deviation is 5, a value of 25 would be 1 standard deviation above the mean; a value of 18 would be 0.4 standard deviations below the mean, and a value of 30 would be 2 standard deviations above the mean).

Percentile

While DRCOG recommends the quartile approach due to its simplicity to understand, any percentile can be used as a cutoff. For example, Figure 4 shows an example from the North Federal Community-Based Transportation Plan, which uses five groupings of tracts, rather than four, adding more granularity. Similarly, if only the most marginalized tracts were of interest, those in the 90th percentile could be examined, while excluding everything else. Local agencies have the flexibility to determine cutoff values that make the most sense for their local area and specific purpose. Use the PERCENTILE function in Excel to determine the cutoffs if using this approach, then categorize tracts according to the range in which they fall based on the results.

Figure 4. Example of Equity Index values using 20% groupings (quintiles)



Benefits and burdens

Every project has the potential to cause both benefits and burdens to the neighboring communities. Project sponsors often consider the benefits of the projects they are implementing, but burdens should be given equal weight. In general, a minimum standard is that marginalized communities should not shoulder a disproportionate share of the burdens of transportation infrastructure in a community and should also not be excluded from the benefits of those projects. Table 1 provides a list of benefits and burdens developed by DRCOG staff, drawn from federal and state guidance and with feedback from community-based organizations.

Table 1. List of benefits and burdens

Topic	Benefits	Burdens
Access	Increases access to opportunities and services for the communities that allow the community to thrive, often through improved connectivity or the lowering of barriers or expanding service areas; improves education.	Reduces access to opportunities and services through reductions in accessibility, including through the construction of facilities that may divide or disconnect a community.
Mobility	Increases access to high-quality mobility choices through the expansion or improved reliability of transit service, active transportation facilities or travel options; reduces costs; improves education; improves ease and comfort of use.	Creates physical, technological or financial barriers that limit or remove access to mobility choices.
Congestion	Mitigates congestion (often through increased reliability and optimized capacity).	Increases traffic congestion.
Environment and health	Reduces exposure to environmental risk factors or negative health outcomes in communities benefiting from the investment.	Increases the probability of exposure to environmental risk factors and negative health impacts (often as a result of increased emissions, noise, air toxins, particulate matter or other harmful pollutants).
Safety	Reduces injuries, fatalities and crashes in communities benefiting from the investment.	Increases the risk or frequency of injuries, fatalities and crashes due to the project (often the result of higher speeds or traffic volumes).

Topic	Benefits	Burdens
Resilience	Reduces the risks and effects of natural and human-created hazards on lives, property, equipment and infrastructure.	Increases the risk or frequency of loss of life, trauma or damage to property, equipment or infrastructure by building in a way that does not account for natural and human-created hazards.
Development	Encourages development that meets the needs of current residents and people of all ages, incomes and abilities.	Increases the risk of displacement of residents or businesses, prioritizes the needs of future or new residents, and may result in further concentration of poverty.

When evaluating which burdens may be tied to a particular project or portfolio of projects, consider the following:

Access

- Is there a community anchor (something that ties the community together and provides important resources) near the project? If so, how does the project impact access to that anchor for people using all transportation modes?
- Does the project aim to support local access, or regional access? Projects that prioritize regional access are important and should be implemented in a way that ensures local access is not hindered.
- Is there a broken or disconnected street grid? In general, a more complete grid can improve local access for people walking, biking, and driving.
- Are the Public Right of Way Accessibility Guidelines followed well, beyond the minimum standards?
- Where does the local community work? Does the project help or hinder their access to their jobs? Does it prioritize access via a single mode at the expense of others?
- Is there a unique destination (for example a community resource for people with disabilities) near the project that requires special access consideration?

Mobility

- Will transportation facilities the community needs be moved or closed due to this project?
- To use the new facility, is there a fee or cost?
- Are other modes of travel hindered (either temporarily during construction or permanently) by this project?

Congestion

- Will the project increase the number of vehicles traveling through a neighborhood, potentially impacting air quality and health?

- Will the project lead to noise pollution in surrounding neighborhoods?
- Will the project lead to longer commute times by private car or by local bus?
- Could the project increase the likelihood of crashes through additional or faster traffic?

Environment and health

- Could the project result in increased noise, emissions, particulate matter from tire wear, or other pollution concerns such as toxic roadway runoff into local water?
- Is there a significant increase in truck traffic anticipated with the improvements?
- Does the project include areas where diesel vehicles congregate and idle, such as a transit maintenance facility or train yard?
- Does the project site include areas which may have contaminated soil?

Safety

- Is the project on the Regional High Injury Network?
- Have any fatal, serious injury, or minor injury crashes have occurred in the project area over the past five years?
- Are proposed vehicle speeds 35 mph or higher?
- If the project is on or intersects with a state roadway, has CDOT identified a high Level of Service of Safety (LOSS), indicating the crash rate for the intersection or highway is higher than that of similar facilities?
- Is the surrounding neighborhood home to lower income households which are more likely to rely on walking and bicycling, potentially in combination with transit, also known as vulnerable road users?
- Are there pedestrian or bicycle attractors in or near the project location, such as schools, transit stops or stations, parks, libraries, recreation centers, commercial centers, and job centers?

Resilience

- Does the project increase impervious surfaces which increase flood chances for neighboring residents?
- Does the project reduce the urban tree canopy or increase paved surfaces? This may increase ground temperatures and expose users to extreme heat during the summer.
- Does the project encourage increased growth in the Wildland-Urban Interface (where the human-built environment runs up against undeveloped land)?
- Does the project generate additional greenhouse gas emissions which may drive further climate change?

Development

- Does the project risk increasing property values in a neighborhood that cannot afford to pay additional property tax?
- Does the project risk rapidly increasing median rent prices?
- Does the project require significant property acquisition for construction, including acquisition and demolition of houses, businesses, schools, community centers, etc.?

Identifying the potential burdens of a project is an important first step toward mitigating or eliminating those concerns. Every project is unique and potential mitigation should be tailored to the specific circumstances of that project. For assistance in mitigating equity burdens including guidance and additional resources, please reach out to DRCOG staff.

Graphic Examples

Example maps and figures to visualize the data. Replicating similar visuals may prove useful to reference or duplicate for local jurisdictions, particularly if included in public-facing documents. All graphic elements should incorporate alt text and meet the visual requirements established by Colorado's digital accessibility law.

Figure 5. Distribution of Equity Index scores in the Denver region

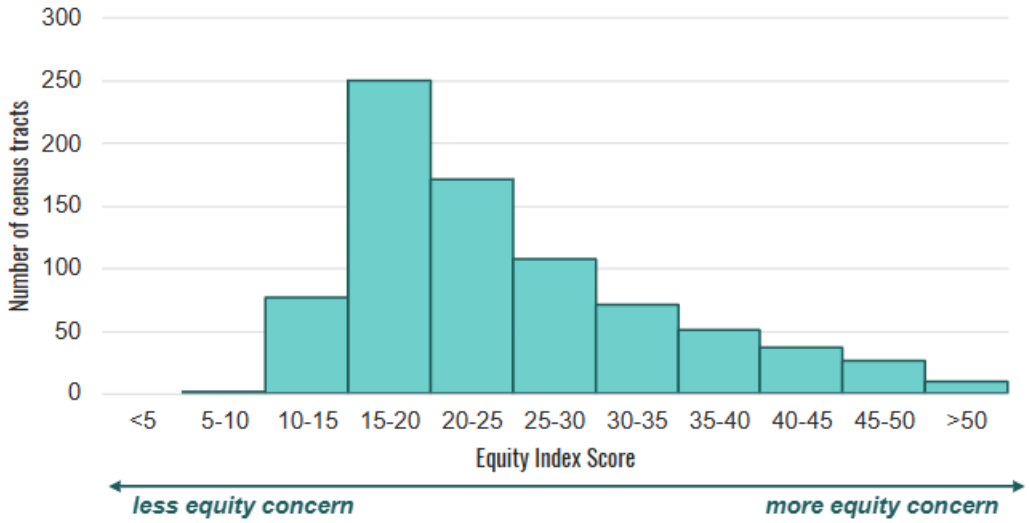


Figure 5 provides the distribution of index scores throughout the region. This is an example of a histogram, with bins of 5. Keeping standard size bins helps to better visualize data and can allow for easier comparison between different geographic areas (such as comparing a county to the region, or comparing multiple neighboring municipalities) as well as to compare different data (reference figures 6 though 8).

Figure 6. Distribution of Economic Status Domain scores in the Denver region

Figure 7. Distribution of Race and Ethnicity Domain scores in the Denver region

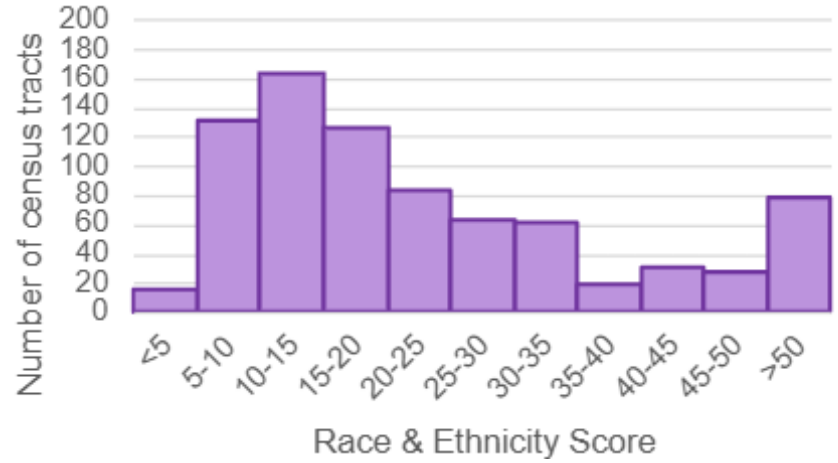
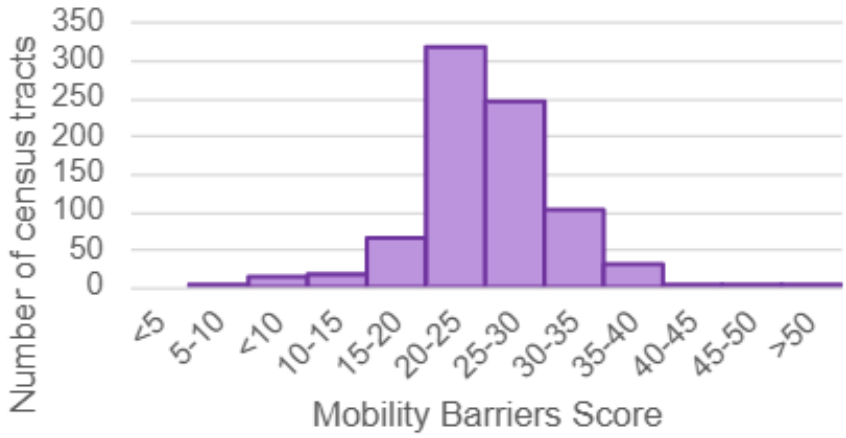


Figure 8. Distribution of Mobility Barriers Domain scores in the Denver region



Figures 6 through 8 keep standard formatting to allow for comparison between the three index domains.

Figure 9. DRCOG Equity Index (this example is zoomed to the metropolitan planning organization boundary)

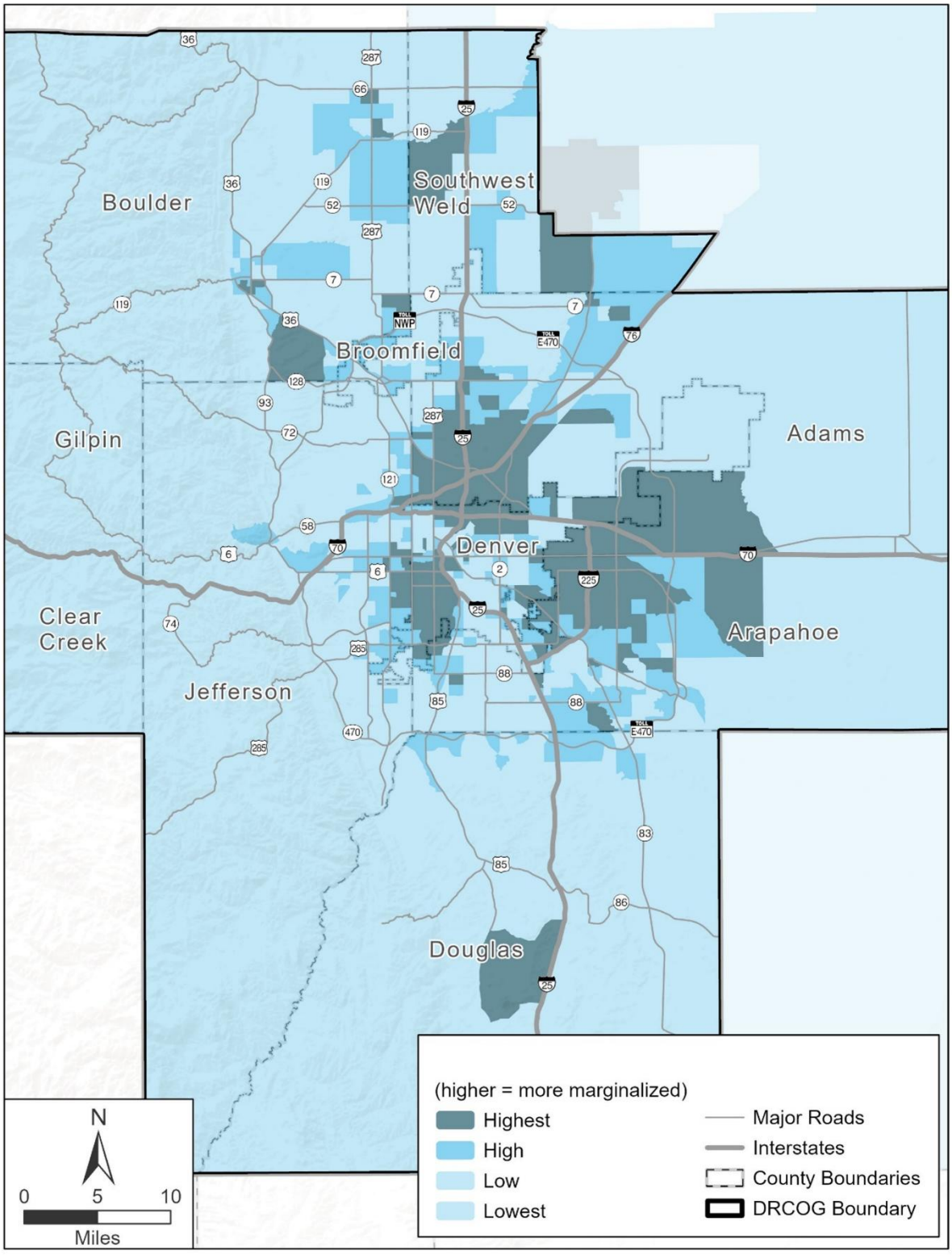


Figure 9 gives an example of the index scores categorized by quartile at the regional level. The equity index is an ordered variable, so symbolize with a value or saturation gradient (the colors should change from lightest to darkest). This method is colorblind-friendly and correctly implies an order to the data groups.

Figure 10. Example quartile analysis, using Transportation Improvement Program active transportation projects

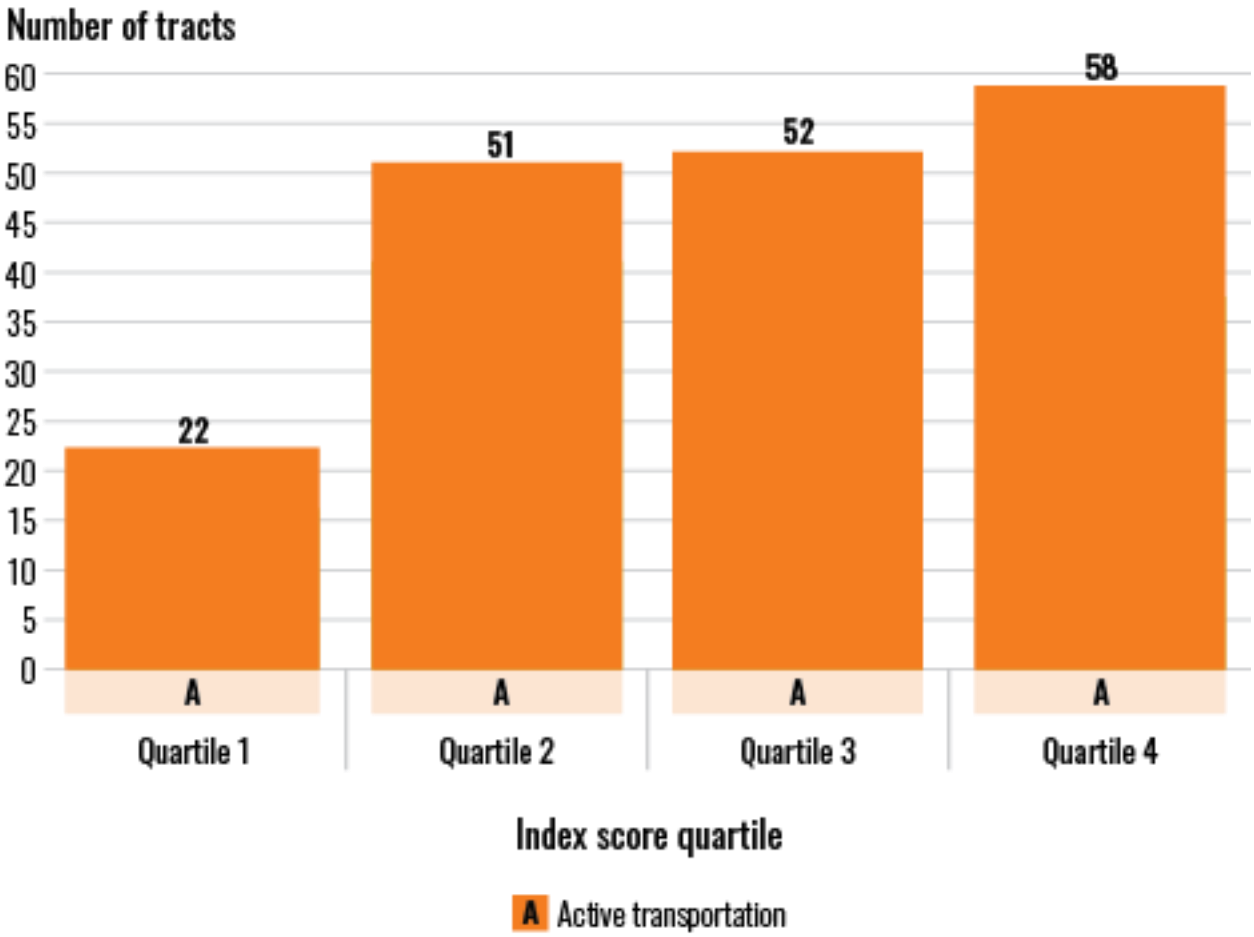


Figure 10 is an example bar chart of quartiles adjacent to a particular project type (a subset of the projects displayed in Figure 2). Note that including the number above the bar assists in legibility as well as accessibility. If displaying multiple datasets (such as multiple project types), be sure to symbolize each in a way that sets it apart, such as by using significant color contrast and providing a text symbol for those who may experience colorblindness (the “A” for Active Transportation in this example).

Figure 11 shows projects mapped compared to the equity analysis quartiles. This can be a very helpful visual tool to spatially compare project locations. It is important that the projects are symbolized so that they stand out from the background data, and are

zoomed to a level that can provide enough detail for the purposes of the plan, study, etc.

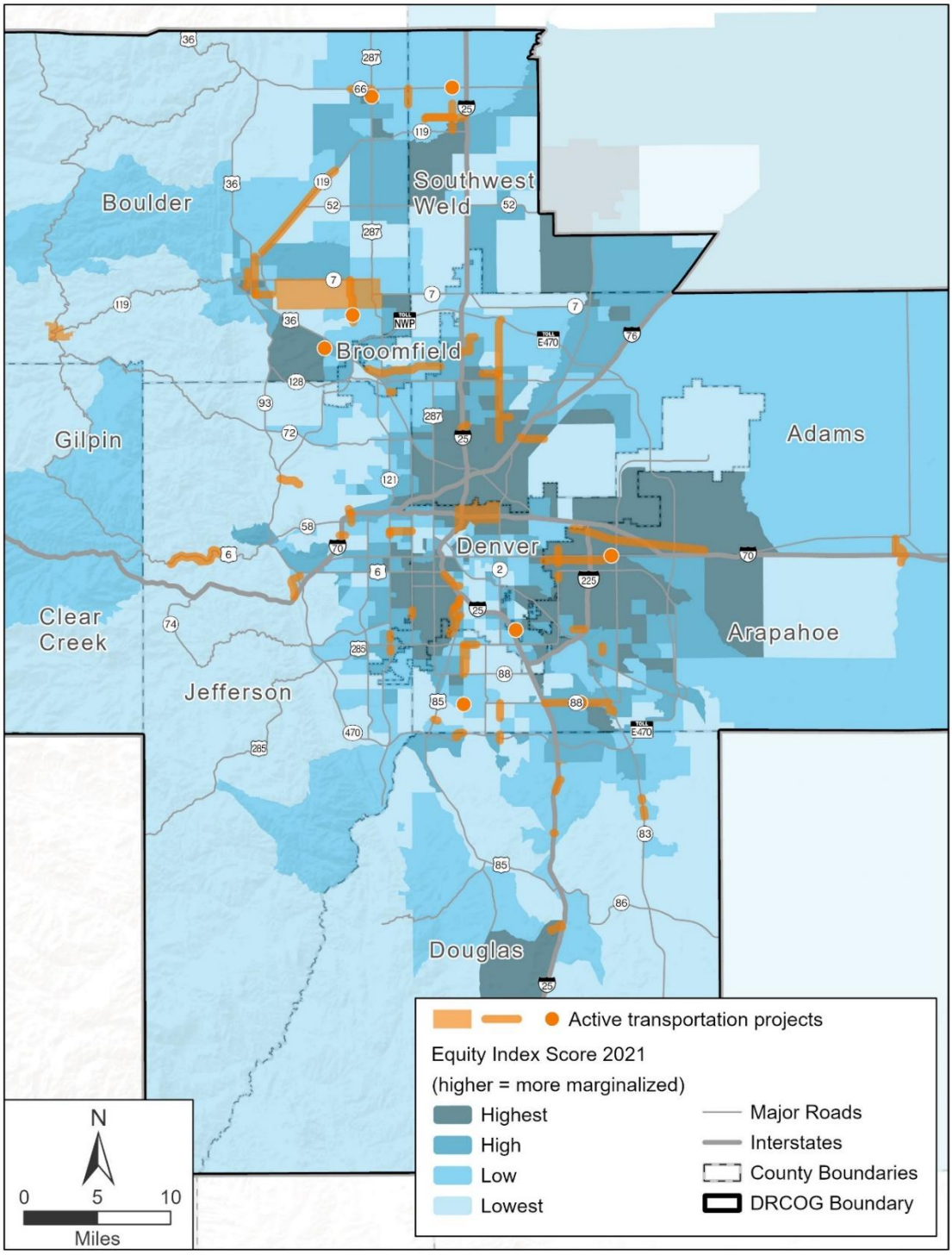



Figure 11. Transportation Improvement Program active transportation projects mapped against the Equity Index