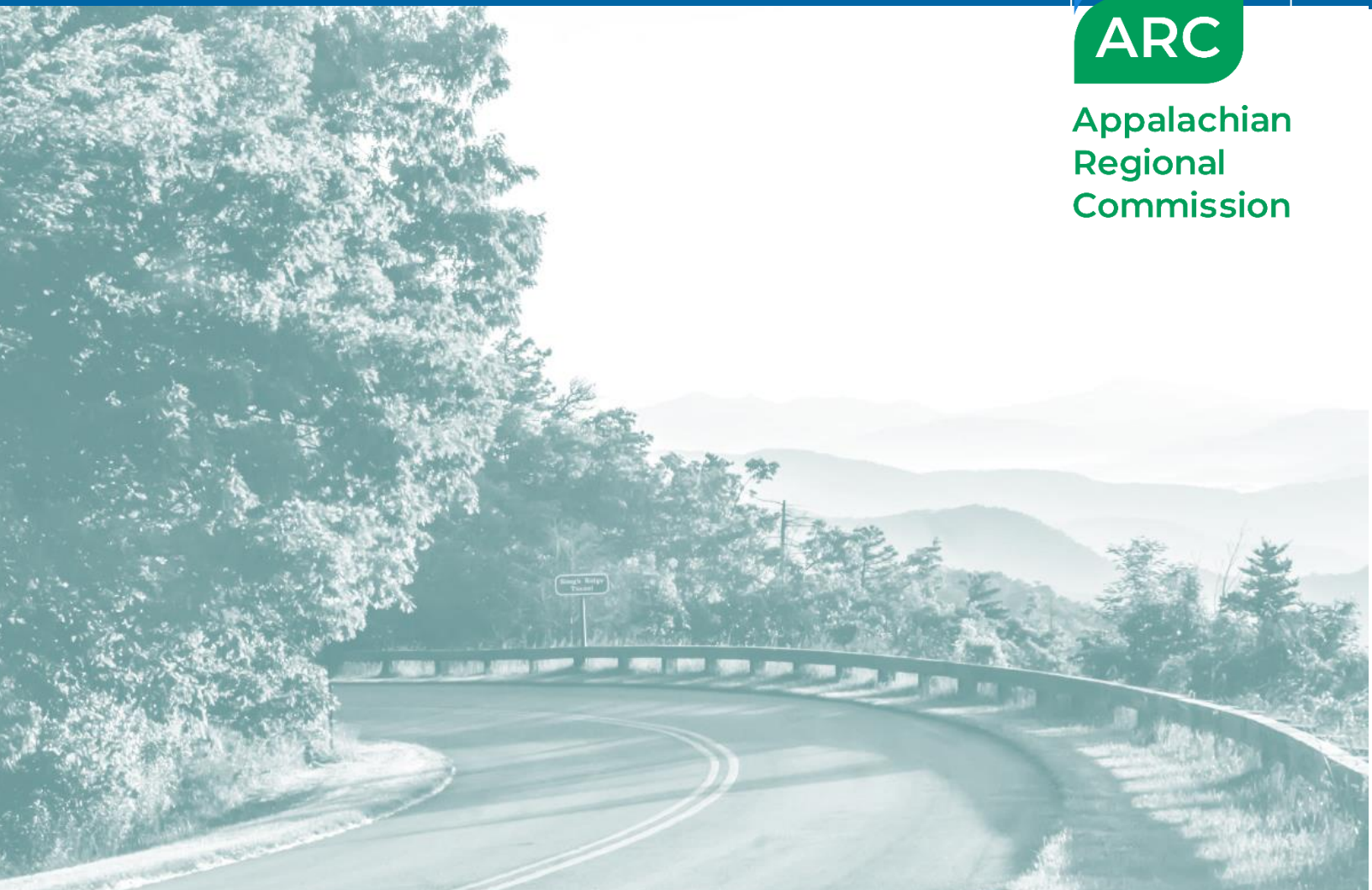




Appalachian
Regional
Commission



Access in Appalachia

A Primer for Measurement and Decision-Making

Acknowledgements

Appalachia Regional Commission

The Appalachian Regional Commission (ARC) provided funding, leadership, and project management for the project. ARC is an economic development agency of the federal government and 13 state governments focusing on 420 counties across the Appalachian Region. ARC's mission is to innovate, partner, and invest to build community capacity and strengthen economic growth in Appalachia to help the Region achieve socioeconomic parity with the nation. Ryan Brumfield, Senior Transportation Advisor, served as the Project Director.

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EBP  EBP US, Inc., formerly Economic Development Research Group, Inc.

Research Report Reference

This primer is derived from the research report “Access in Appalachia” developed by ARC, together with EBP (formerly EDR Group), as a methodological framework for accessibility measurement specifically for the needs and purposes of the Appalachian Region. The report can be downloaded from www.arc.gov

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Primer Purpose and Audience

Why Consider Access in Transportation Planning?

Why Consider Accessibility? The field of transportation planning has been evolving in recent years, with growing recognition of the importance of “accessibility” as a central objective and performance measure. Accessibility refers to the ability of people to reach desired destinations and activities (or conversely, the ability of business activities to reach workers and customers). This is the fundamental reason why transportation infrastructure and services exist, yet the concept had until recently been difficult for many transportation agencies to measure. While measuring travel times and costs is still a major part of benefit evaluation, agencies today can now make use of new datasets and tools to measure and monitor levels of accessibility in their jurisdiction and utilize this information to make more effective investment decisions. This document shows how.

The need to measure and improve accessibility is particularly important for regions of the United States, including Appalachian States, where there are constraints on accessibility and challenges for economic development due to topographic, service availability, and spatial factors. The Appalachian Regional Commission was established in part to help address the Region’s isolation and accessibility limitations, and since its founding has worked with its partners across the region to improve access and economic opportunity. The primary goal of the Appalachian Development Highway System (ADHS) is to help reduce isolation and better connect residents of the Appalachian Region to broader markets. Although the ADHS is now nearly 90% complete, many parts of Appalachia still suffer from isolation and poor access. Thus, it becomes important for state and regional agencies to take further action to improve accessibility to jobs, health care, and education for their residents.

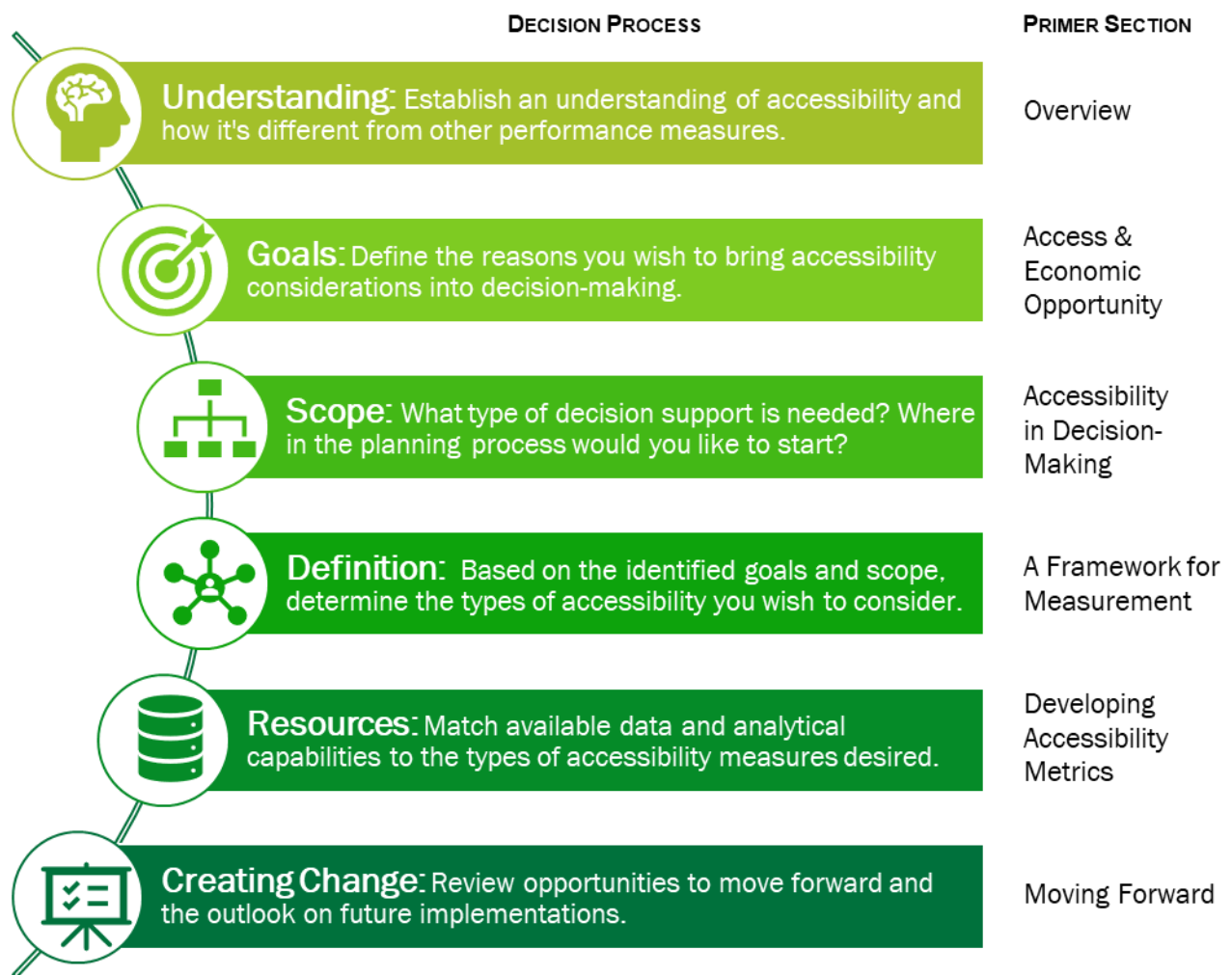
Primer Purpose. This primer is designed to:

- Provide a simple overview of what access is and why it matters
- Highlight the link between access and social and economic opportunity
- Outline the types of access that are most relevant in Appalachia
- Provide guidance to effectively incorporate accessibility in transportation decision-making by making use of available information sources and analysis methods.

Audience. This primer is intended for use by transportation and economic development professionals in state, regional, and local government. Those who have never explored accessibility concepts and measurement approaches will find guidance on where to start. More seasoned analysts can use this primer to understand how accessibility analysis can extend beyond the traditional focus of access to jobs to other types of access, and to learn about special consideration for accessibility in rural areas. This primer is particularly appropriate for those tasked with directing transportation investments based on assessments of needs and opportunities.

Structure. The primer is structured to mirror the process for building accessibility considerations into decision-making, as shown in Figure 1. It starts with an overview to give readers an **understanding** of accessibility concepts. The second chapter focuses on the *goals* of accessibility measurement, namely support for economic development. The third chapter situates accessibility within the decision-making process, to help readers determine the *scope* of their analysis. The fourth chapter dives into different **definitions** of accessibility that can be employed to address the needs of businesses and people. The fifth chapter focuses on the process for assembling data and analytical **resources** to implement selected measures. Finally, the last chapter addresses opportunities to **create change** and how ARC and its partners can move forward together.

FIGURE 1 SIX STEPS TO BUILD ACCESSIBILITY CONSIDERATIONS INTO DECISION-MAKING



Overview

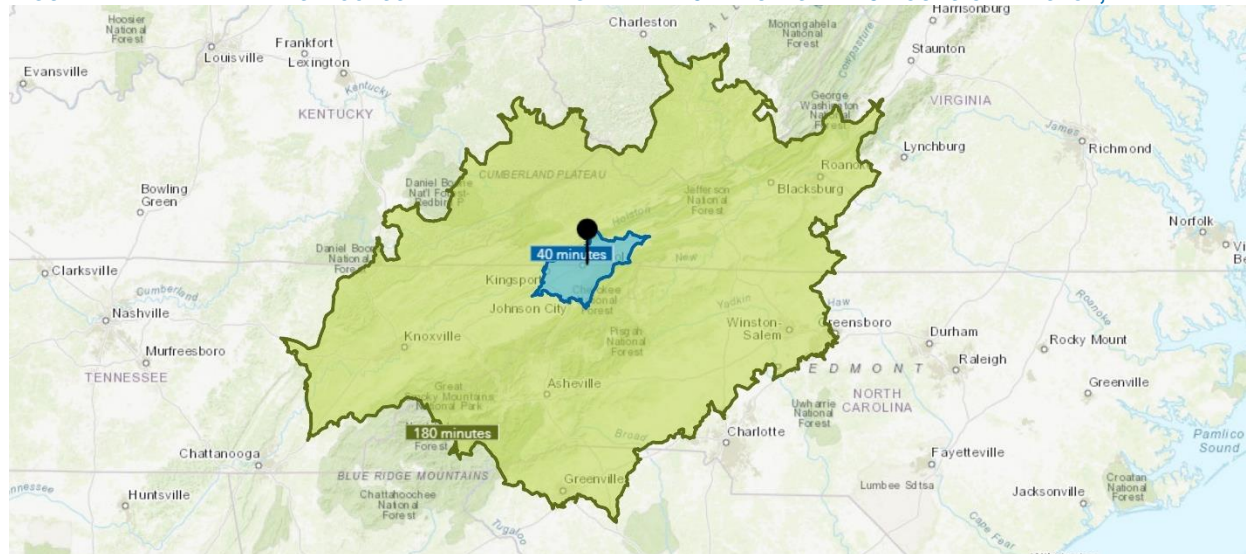
What Is Accessibility?

A Focus on Opportunities

Definitions. Accessibility refers to the ability of people and businesses to reach activities, services, and goods given available transportation options. It is a way of quantifying how many activities are reachable within a given level of effort. For example, in Figure 2, one could count how many customers a company can reach within a three-hour drive of a location in Bristol, Virginia.

Accessibility addresses not only where people or goods currently travel, but the *potential* or *opportunity* for interaction, based on where they could travel.¹ Accessibility levels depend on (1) how many destinations are within a certain area and (2) a person's (or shipment's) level of mobility, or ability to travel between places.² Passenger transportation provides access to activities that people value, including work, shopping, recreation, health care, and education. Freight transportation ensures that households can purchase goods and provides businesses with the ability to ship and receive supplies and finished products. Each of these destination types represents a form of economic or social participation. In places with low-density settlement patterns like Appalachia, accessibility can be particularly dependent on levels of mobility, given the distances between relevant activities.

FIGURE 2 EXAMPLE—AREAS ACCESSIBLE BY DRIVING WITHIN 40 MINUTES AND 3 HOURS OF BRISTOL, VA



Source: Produced by EDR Group (now EBP) using Esri Business Analyst Online.

Access and economic development. Accessibility is essential for economic development. Businesses of all types rely on the transportation system to access workers, inputs, markets, and collaborators. Places reliant on manufacturing or resource extraction tend to be proportionally more

concerned with freight access to supplier and customer markets via transportation connections. Places that are service-oriented, on the other hand, have proportionally greater requirements for access to skilled workers, broadband, and educational institutions.

Accessibility improvements can generate economic development by attracting new businesses to a region or increasing the productivity of existing businesses. When businesses decide where to open new locations or relocate, many list accessibility factors among their top criteria.³ Through increased market access, firms can increase their sales and use capital and labor more efficiently. The term “agglomeration economies” refers to the business productivity benefits associated with industry clustering and improved access to workers, suppliers, and customers. These economic forces tend to encourage spatial clustering at various geographic scales and lead to firms being more productive when they have better access.⁴

Accessibility is also necessary for ameliorating economic distress. The World Bank considers “access for all to economic and social opportunities” as central to their mission of reducing poverty and improving health and human development outcomes.⁵

Challenges in Appalachia. Remote areas like those throughout Appalachia tend to be poorly served by freight and transit operators due to lower demand. Because of the effects of poverty and aging in Appalachia, specific accessibility challenges arise for people who lack access to a personal automobile and therefore have difficulty reaching jobs, school, or other destinations. Some areas also have limited roadway network coverage because of high construction costs associated with topographical barriers like mountains or rivers, coupled with less dense settlement patterns and other spatial constraints.⁶ Each of these challenges can make access in rural areas a major impediment to people’s well-being and businesses’ economic viability.

Recognizing both the opportunities associated with good access and the considerable challenges derived from constrained access, access measurement is a way to better understanding opportunities, pinpointing problem areas, and providing a platform for action.

Three Dimensions of Measurement

Accessibility measures typically address three dimensions as shown in Figure 3: (1) the user group, defining the perspective of the measure, (2) the attractions, destinations, or opportunities to which access is being considered, and (3) network availability and performance, which dictates whether trips are possible by a given mode and how easy or hard the connection is.

FIGURE 3 THREE DIMENSIONS OF ACCESSIBILITY DEFINITION

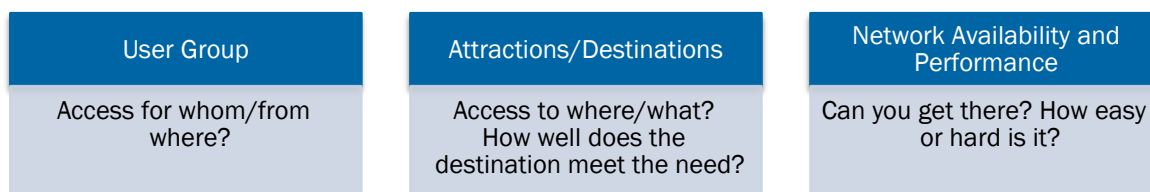


Table 1 describes at a high level the options available for each of these dimensions, along with guidance and special considerations for rural areas. Because access measures always assess opportunities that are accessible from a given location, the user group options represent

different choices on how to select that starting point when conducting an analysis of access across a region. The options for attractions/destinations address the question of how to represent the number and importance of accessible opportunities. Finally, the network availability and performance options relate to which attributes of transportation system performance and which networks should be considered when trying to determine the relative ease or difficulty of accessing a given opportunity. Not included in this table is guidance on how to determine which opportunities are “counted” as accessible—i.e., how travel time/distance/cost mediate the value of accessible opportunities. This is addressed through the functional form of an accessibility measure, which is discussed in the next section.

TABLE 1 OPTIONS AND CONSIDERATIONS FOR DEFINING AN ACCESSIBILITY MEASURE

	Options	Considerations and guidance
User Group	Measure access for users based on analysis of access: <ul style="list-style-type: none"> From all centroids within a zonal system From all cells in a standard grid From key locations (e.g., major employment centers) For all zones or cells, but weighted by the number of users affected 	<ul style="list-style-type: none"> Using standard geographic units (e.g., from the Census) can help with reproducible comparisons across different areas Consider weighting accessibility scores by affected users, particularly in sparsely developed rural areas Consider also weighting scores by measures of economic disadvantage (to focus on equity)
Attractions / Destinations	<ul style="list-style-type: none"> Counting discrete opportunities (e.g., number of schools) Defining hierarchies of importance by granting a greater number of points to activities of a certain kind, quality, or scale (e.g., more points for a level I trauma center than levels II–IV). Counting using indicators of magnitude (e.g., population or employment). 	<ul style="list-style-type: none"> Prioritize destinations based on a hierarchy of needs, guided by planning goals or stakeholder input Given the sparseness of the transportation network in some parts of Appalachia, measures that focus on network rather than activity access (e.g., access to rail terminals, ports) may also be appropriate.
Network Availability & Performance	Units of “impedance:” <ul style="list-style-type: none"> Travel distance Travel time Travel cost Network definitions: <ul style="list-style-type: none"> By mode (e.g., drive, transit, walk, bike) Time of day Truck restrictions/routes 	<ul style="list-style-type: none"> Travel time is the most commonly used “impedance” measure as it both conveys outcomes of transportation network performance from a user’s perspective and is easy to interpret Given the significant challenges faced by those without private vehicles, consider analyzing non-car accessibility Depending on the focus of analysis, other units of “impedance,” such as generalized cost or special network definitions (i.e., truck networks), may merit consideration





Source: ARC

Common Measurement Forms

Accessibility measures are designed to reflect the fact that destinations that take more time to access are, all else equal, less desirable or useful than those located close by. Moreover, at some point travel times become unreasonable and a destination should be considered effectively inaccessible. The manner in which this underlying logic is incorporated into accessibility measures varies and falls into two primary categories:

- *Contour measures.* These include all activity reachable within a given travel time threshold.
- *Potential/gravity measures.* These sum all activities in an area of analysis, weighted such that opportunities that take more time to access are granted less weight than those close to the point of origin.

There are also approaches where measures only address access to the *nearest destination*. This implies either that access to additional destinations after the first one is not meaningfully better and/or that the purpose of the analysis is address a basic form of minimal access or sufficiency. Intermodal connectivity is often treated this way (i.e., access to the closest airport). In this situation, there are a few distinct measurement options:

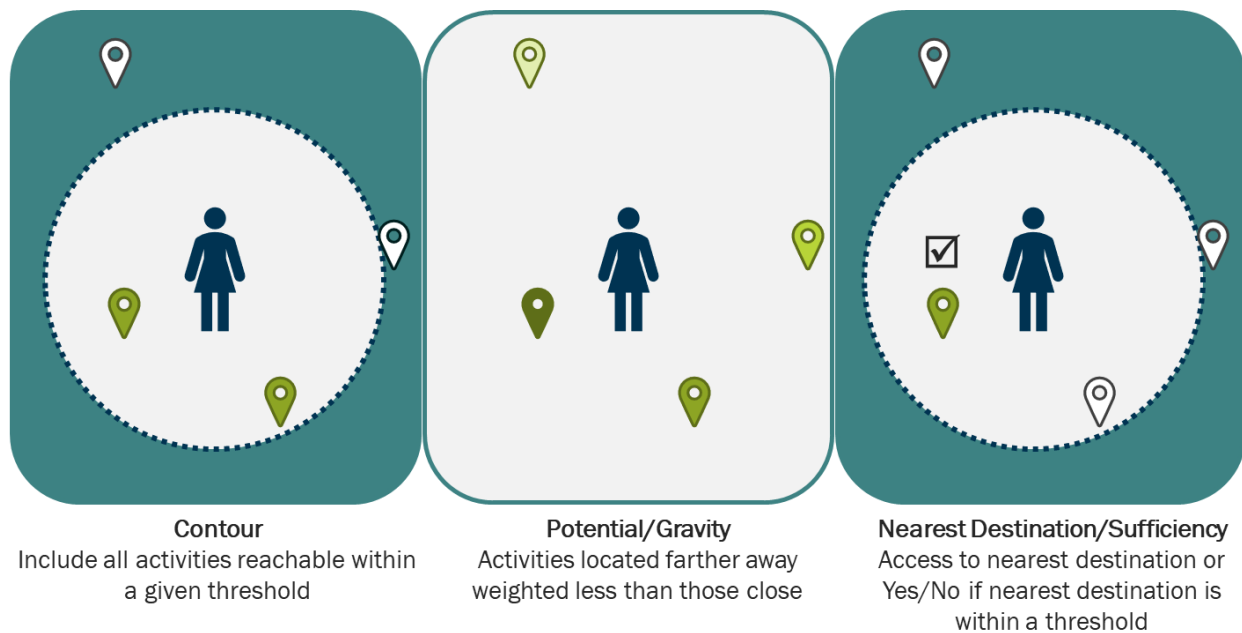
- Measuring travel time to closest opportunity.

- Constructing a measure of the general form where $\text{Access} = (\text{Measure of the importance of the destination}) / (\text{Travel time})$. For example, one might measure volume at the port as a proxy for its relative importance.
- Binary sufficiency measures. i.e., a yes or no as to whether at least one destination is accessible within a defined threshold.

Figure 4 illustrates how these different functional forms of accessibility measures would treat the same spatial configuration of users and destinations. Note that these diagrams are presented in terms of straight-line distance (meaning thresholds appear as circles) but actual measures would use travel time and therefore not have perfectly circular boundaries.

In the case of the contour measure, only the two destinations within the threshold matter. They also “count” at the exact same level of importance even though one is considerably close. The diagram also highlights the somewhat arbitrary nature of threshold selection. The third closest destination lies just outside the boundary but is treated as providing no value, compared to the one just inside the threshold. On the other hand, the potential/gravity type measure instead recognizes all the destinations along a continuum of importance based on how far away they are. Finally, the nearest destination/sufficiency type measures only recognize the one closest destination, with all others treated as irrelevant.

FIGURE 4 ILLUSTRATION OF DIFFERENT FUNCTIONAL FORMS OF ACCESSIBILITY MEASURES





Source: ARC

Table 2 presents some of the pros and cons of contour versus potential/gravity measures. They each have strengths and weaknesses for different audiences and applications.

TABLE 2 PROS AND CONS OF CONTOUR V. POTENTIAL/GRAVITY MEASURES⁷

	Pros	Cons
Contour	<ul style="list-style-type: none"> Easier to interpret, communicate, calculate May be more attractive to general users/high-level decision makers 	<ul style="list-style-type: none"> Thresholds are inherently arbitrary No differentiation of opportunities within isochrone Can be very sensitive to travel time changes, which can make it harder to use in evaluating changes
Potential/Gravity	<ul style="list-style-type: none"> Addresses many of the theoretical issues of contour measures May be more attractive to researchers interested in detailed comparisons 	<ul style="list-style-type: none"> Harder to interpret/communicate Requires selection of a specific decay function



Selecting Thresholds or Distance Decay Functions

Thresholds or parameters of spatial decay functions are typically chosen to reflect travel behavior. In practice, this can mean either (a) selecting “rule of thumb” thresholds (e.g., 60 minutes), or (b) selecting thresholds or parameterizing decay functions through analysis of empirical data on spatial travel behavior. The latter approach relies on data describing the distribution of trip durations, stratified by variables of interest—namely trip purpose, mode, and location/area type.

The National Household Travel Survey (2017) offers a recently updated national data set of this type, but individual regions and states may have their own data from custom surveys.

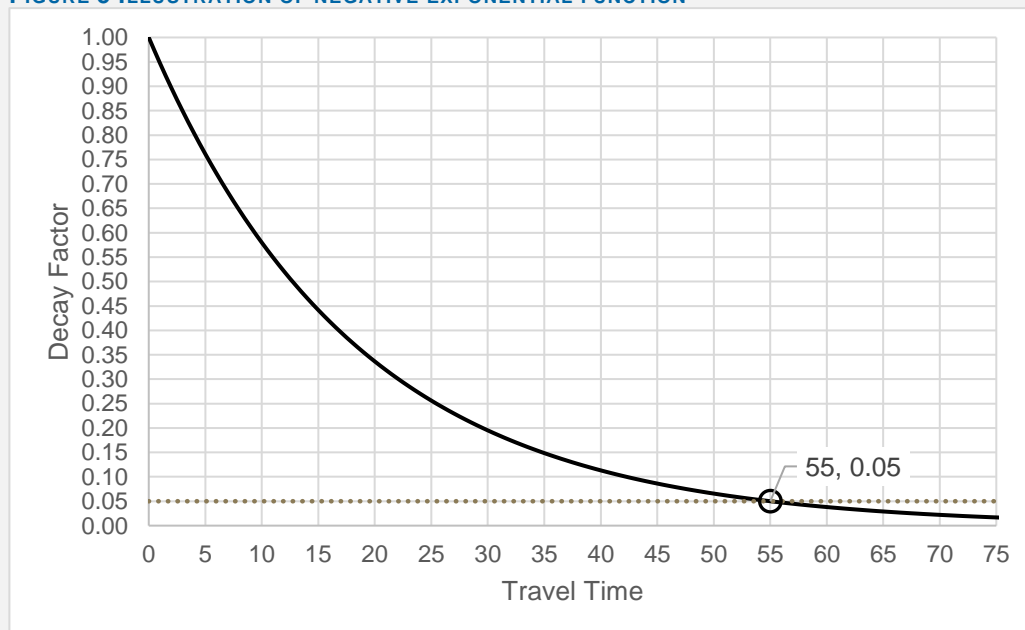
Negative Exponential Functions: Spotlight Example

For potential/gravity measures, the most common functional form is a negative exponential function of the form:

$$A_i = \sum_{j=1}^n D_j e^{-\beta t_{ij}}$$

Where A_i is the accessibility of zone i to all destinations in other zones (j) and t_{ij} is the travel time between zone i and zone j . D_j is a measure of the importance of destinations in zone j . Here β determines the shape of the decay function that mediates the opportunity offered by the destinations. Where travel time is zero, $e^{-\beta t_{ij}} = 1$, meaning the full measure of the importance of the destination is counted. For any travel time greater than 1, that factor becomes a fraction reducing the weight given to the destination opportunity. One approach to choosing the parameter β is to find the 95th percentile of travel time for a mode/trip purpose/region type of interest and then set β such that if $t_{ij}=t_{95}$, then $e^{-\beta t_{ij}} = 0.05$. For the sake of illustration, if travel data shows that 95% of school trips are less than 55 minutes in duration. This would mean a β of approximately 0.054 calculated as described previously and would yield a decay function of the shape shown in Figure 5.

FIGURE 5 ILLUSTRATION OF NEGATIVE EXPONENTIAL FUNCTION



Access and Economic Opportunity

How Does Accessibility Support Economic Opportunity?

Access Needs

Accessibility is about connecting people and businesses to the activities and resources they need to participate fully in the economy and society. The following table summarizes key types of access, as identified from research literature on economic development and opportunity.

People and Businesses Need Access To...



Jobs and Workers–Labor Market Access

Businesses are more productive when they have access to broader labor markets as this enables better matching between their requirements and the skills of available workers.⁸ This is proportionally more important for service or knowledge-based industries, but workforce is, in fact, one of the top site selection criteria across all industries.⁹ Accessibility is also key to ensuring people can access and maintain gainful employment. In places with high unemployment, improving access can increase the number of job opportunities available to residents.¹⁰



Customers, Suppliers–Access to Goods and Services

Businesses also need access to their customer base, whether that's individual consumers or other companies to which they provide goods and services. Conversely, businesses are also dependent on transportation for access to suppliers, whether of material goods or of services that require in-person support. Transportation access can dictate the effective service area of businesses, defined either by people's willingness to travel, or by the performance of freight transportation networks in supply chains. Customer access can range from very local (e.g., for a convenience store) to highly global (e.g., for a specialized manufacturer). Nevertheless, research shows that same-day truck delivery markets are particularly important indicators of competitiveness.¹¹ Finally, providing access to consumer goods and services is a fundamental purpose of transportation and can make a community more attractive.



Network Access - Intermodal Terminals and Key Nodes

Connectivity to long-distance transportation networks (airports, marine ports, intermodal rail) broadens the geography of market access, particularly in a globalized economy and may be considered as its own dimension of access as well. For example, in Amazon's highly publicized request for proposals for a second headquarters, the company defined a set of minimal transportation access

requirements including “Proximity to major highways and arterial roads” within 1–2 miles and “Proximity to International Airport” within approximately 45 minutes.¹²



Access to Education

Economic development may be hindered where potential students do not have good access to colleges and other schools and where employers do not have access to an adequately educated workforce. While 42% of the nation’s young people between age 18 and 24 are enrolled in a higher education institution, only 29% of rural people are.¹³ While there are other individual and social barriers to higher education, research shows that distance to college also correlates with students’ choices to apply or enroll. This is the case even more so in rural areas, since lower socioeconomic status is more common in rural areas and substantial savings can be achieved when college students are able to live at home.¹⁴ For many rural people, community colleges provide the only accessible opportunity for higher education. About two-thirds of public two-year colleges serve rural communities, providing a critical path to careers and four-year universities.¹⁵ Research has shown that rural counties with an established community college or university have experienced greater job growth over time than counties without institutions of higher education.¹⁶



Healthcare Access

The ability to access medical care is critical to the overall health and welfare of society. This is especially true for vulnerable rural populations, including older adults, people with disabilities, low-income individuals and families, and veterans or those who otherwise have unique healthcare needs.¹⁷ Lack of accessibility to care can lead to delayed or missed appointments, disruption to care for chronic conditions, increase in stress for patients, and decline in use of some medication.¹⁸ Approximately 3.6 million Americans miss or delay non-emergency medical care each year because of transportation-related issues.¹⁹ Older adults tend to have lower mobility levels, which negatively affects their ability to access health facilities and services.²⁰ Vehicle availability is also consistently associated with increased access to health care.²¹ Out of the 420 counties in the Appalachian Region, 149 rank in the worst national quintile regarding years of potential life lost (YPLL).²² Transportation is one of three main barriers to health care for rural populations.²³ Opioid addiction is considered a public health epidemic in the United States and especially in some Appalachian states. Opioid deaths and injuries have increased the most in rural areas where emergency medical response times are longer. In addition, opioid addicts living in rural areas face greater barriers to treatment given a lack of public transportation and longer travel distances relative to urban areas.²⁴



Broadband Availability and Access

In an increasingly networked economy, broadband connectivity is critically important to the business community, contributing to increased productivity, competitiveness, and efficiency.²⁵ Access to broadband internet is also increasingly being recognized as a prerequisite for people’s access to various other services, such as health care, education, employment.²⁶ While only 7% of the United States’ population does not have broadband access in their neighborhoods (25 Mbps download or faster), in rural America this share is 27.4%.²⁷ Where educational institutions, health care providers, and employers are not sufficiently accessible to people, broadband access can serve as a partial substitute for physical access.

Transportation Barriers to Access

While accessibility is a product of both the spatial pattern of available activities and the transportation system, there are cases where transportation creates a barrier to access. The most commonly cited transportation access barriers are described below.

Transportation Barriers to Access



Vehicle Availability / Ability to Drive

Even though driving is the predominant mode for most people in Appalachia, those without vehicle access or who cannot or choose not to drive face particularly harsh barriers to access in rural areas where transit service is sparse or non-existent and where distances to desired destinations are considerably longer. This barrier is exacerbated by poverty and the aging population of many rural communities.



Network Coverage

Some areas have limited roadway or rail network coverage because of high construction costs associated with topographical barriers like mountains or rivers, coupled with less dense settlement patterns and other spatial constraints.²⁸



Service Availability and Scheduling

Remote areas like those throughout Appalachia tend to be poorly served by freight and transit operators due to low demand. When service is available, schedules may be inconvenient and create significant schedule coordination burdens.



Geometry

The physical design of a roadway can constrain the ability of larger trucks to pass. Relevant dimensions include road width, clearance, turning radius, weight limits, and the existence of passing lanes or shoulders. Similarly, some rail routes may lack the vertical clearance for double-stacked container movements.



Congestion

Particularly in the vicinity of more urbanized areas and major terminals, congestion can constrain mobility. Delay and unreliability associated with congestion reduce the number of activities that can be reliably reached within a given time and cost and thus reduce the level of access provided by the transportation system.

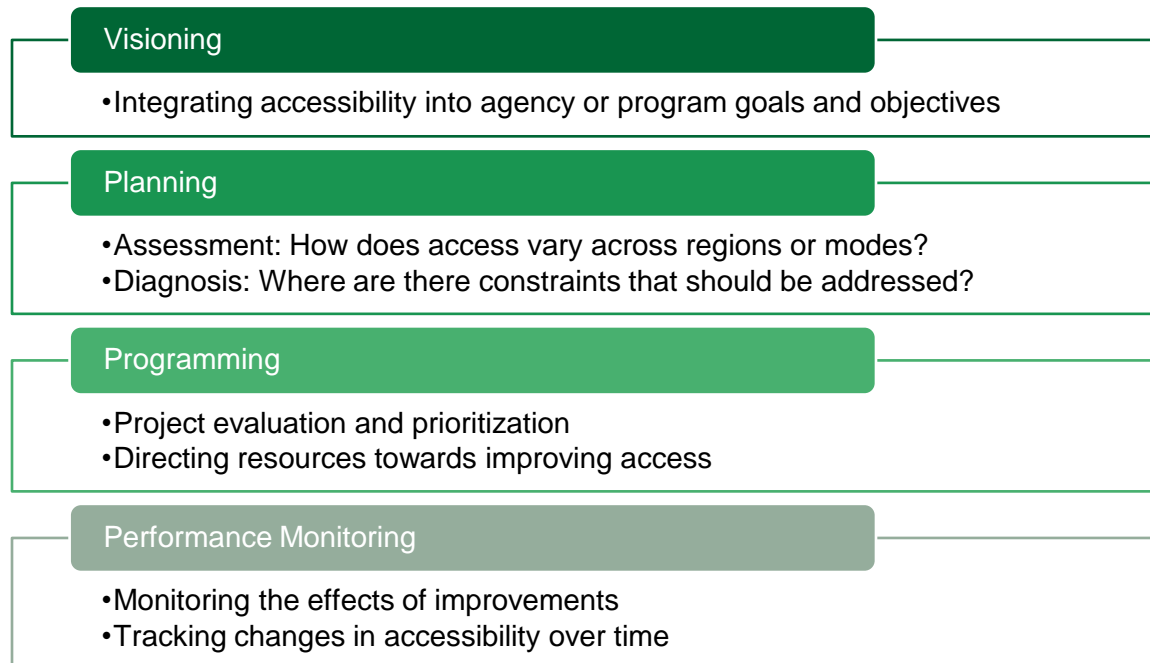
Accessibility Measurement in Decision Making

How Can Accessibility Measurement Help?

The Planning Process

Accessibility concepts and measures can be integrated into all phases of the transportation planning process as shown in Figure 6.

FIGURE 6 ACCESS IN PERFORMANCE-BASED PLANNING AND PROGRAMMING



Before pursuing any form of analysis, or evaluation it is important to start at the visioning step. Here, an agency should define how accessibility fits into its mission. Accessibility can be integrated into the goals and objectives established for an entire agency or plan, or it may be the focus of a specific program. For example, some state departments of transportation fund economic development access programs that provide funds for building connections to new development sites or community resources.²⁹ Acknowledging access as an explicit goal or objective helps communicate the intention of subsequent planning and motivates the use of access measures to guide decision-making.

Subsequently, within the planning process, access measures can be used in assessment and diagnosis to determine how access varies across regions or modes and to identify constraints that may need to be addressed through transportation improvements. Accessibility analysis can

be integrated into state and metropolitan planning organization (MPO) long-range plans in the context of evaluating current or forecasted future needs. Developing data and maps highlighting areas with lower levels of access can support the targeting of investments both by those developing the plans and by local planning partners.

Moving from broad diagnostics to developing programs of projects, access measures can serve as criteria for project evaluation and prioritization. In this context projects can be scored based on (1) the level of existing accessibility constraint in the areas served, (2) the degree to which the proposed project would ameliorate that deficiency, or (3) some combination of the above. Scoring can be based on quantitative access measures or may involve qualitative scoring (e.g., from 1 to 5) based on the judgement of planners with local knowledge. Incorporating accessibility criteria into prioritization helps decision-makers direct resources towards their goal of improving access in a way that is transparent and consistent across projects.

Finally, access measures may be incorporated into performance monitoring to track changes over time, including monitoring the effects of project improvements. This is perhaps the least developed area of access measurement but represents an opportunity as states and regions more fully implement federal guidance on performance-based planning and programming.³⁰ To build accessibility into performance monitoring requires measurement approaches that use data that is cyclically and consistently updated over time. While federal sources such as the U.S. Census Bureau provide this for many forms of activity data, transportation network performance data is more varied in its availability and how frequently it is updated. Data availability is discussed more fully in the section that starts on page 16 of this primer.



Source: ARC

Comparative Analyses

Accessibility measures, like many performance measures, are most useful for decision support when interpreted comparatively. This can include:

- **Comparing across places** to identify locations that face access disadvantages. For example, one might choose to focus specifically on areas within the bottom 10% of accessibility scores.
- **Comparing relative to benchmark or standard of acceptable access.** For example, a 2002 directive from the Ministries of Health Services and Health Planning in British Columbia, Canada, sets minimum requirements for access to acute health care, including “Access will be provided to emergency services on a 24/7/52 basis within a one hour travel time for 98% of residents within the region.”³¹
- **Comparing accessibility with and without a project.** To make a comparison, an analyst must use forecasting tools to estimate changes in travel time or cost from a transportation project and calculate the accessibility metric in both the base and build cases.
- **Comparing among projects.** Particularly for prioritization, projects can be ranked according to their accessibility or their accessibility improvement scores. Alternately, accessibility scores may be integrated into a weighted multicriteria evaluation framework where projects are ranked according to composite performance across many categories.
- **Comparing over time.** As describe above, this supports performance management and tracking of how well transportation agencies are meeting their goals.
- **Comparing across user groups.** Sometimes specific groups are disproportionately affected by access constraints. In this case it can be helpful to compare accessibility across user groups. For example, one might weight accessibility scores by measures of the number of people below the poverty level in that zone or by the proportion of households without cars. Alternately, an analyst might first select areas that fall below or above a certain threshold—i.e., a designated level representing high unemployment—and then compare accessibility scores for areas in that subgroup to accessibility for those that are not.

COMPARE

- Across places
- Relative to a standard
- With and without a project
- Among projects
- Over time
- For different users

Application

The application of access measurement to decision-making includes (1) a combining of spatial and transportation network data in an analysis to understand what is accessible from different points in a region. This information is then used (2) in a comparative fashion to rank levels of access across communities. Finally (3), when considering projects, this information can be used to give greater priority to projects that address current access deficiencies and are expected (or modeled) to yield access improvements. Within a planning process, steps 1 and 2 might happen in the context of a long-range plan or special study, while step 3 could occur in the context of programming projects.

A Framework for Measurement

Focus on the Success of People and Businesses

Key Metrics

Both people and businesses rely on access. While businesses need access to labor, suppliers, and markets to be economically successful, people need access for both economic and social well-being.

As people's needs are not limited to work, destinations to be considered go far beyond potential employers. Education, health care, shopping, and recreation are also needs that people have and should be addressed. Corresponding destinations should also be accessible and are of great importance for economic outcomes. Education provides qualification for a wider range of jobs with higher earnings; accessible health care supports people's workforce participation and productivity; and recreational opportunities help people stay healthy, make communities more attractive, and can themselves be a driver of economic activity.

Such a broad view of accessibility requires a wide range of accessibility metrics. As described in Figure 3, the *user group* and the *destination* are their main descriptors. In their combination, the user group may make a metric more specific by defining for whom the specific destination is important. Schools as a destination, for example, are most important for students under age 18.

Theoretically, a system of metrics based on all possible combinations of user groups and destinations, including the mode by which the destination can be reached, would give full flexibility to choose the metrics that seem most appropriate for the intended use. However, to focus analysis on what is most important, it is helpful to limit the number of metrics. Appalachia serves as the guiding principle for that step.

The following suggestion of key metrics is based on a literature review and on interviews within the Appalachian Region. The set of metrics is intended to cover major accessibility, businesses and people may have. Additional detail on the reasons behind these selections and the types of data that can be used to support these measures can be found in the full research report, *Access in Appalachia: Concept and Methodologies*, available on the ARC website. The report also lists complementary metrics that can add information and address individual agency needs.

Access for Businesses

Businesses have three main access needs: for workers, supply chain, and delivery. Intermodal nodes may serve as destinations for both supply chain and delivery to extend the geographic reach of businesses.

As destinations for specific businesses are unknown and can only be captured in the abstract, the spatial distribution of employment is suggested for use as a representation of potential suppliers, while the distribution of population may serve as the representation of potential consumers.

TABLE 3 SUGGESTED KEY METRICS FOR BUSINESSES' ACCESS

Business Specification	Access to ...		Destination Specification
All	Labor		Associate's or higher
Manufacturing	Supply chain		Employment
All			
Trade & Warehousing	Delivery	Consumers	Population
Manufacturing and Trade & Warehousing	Intermodal connectivity	a) Rail facility	All freight rail facilities
		b) Port	Coastal port
		c) Airport	All
All			

Access for People

People's needs to access places center on employment, education, health care, shopping, and recreation. While some of these destinations are important to everybody, employment and education are more important for certain age groups than for others. Defining the user group more specifically may help the metric to portray accessibility more accurately. Note that town centers were identified as a way to represent locations where retail and other services tend to be concentrated in rural areas.

TABLE 4: SUGGESTED KEY METRICS FOR PEOPLE'S ACCESS

Population Specification	Access to ...		Destination specification
Age 18–65	Job		Employment
Age 18–24	Education	College	All
All	Health care	a) Primary care	General practice
		b) Trauma center	All
		c) Addiction treatment center	All substance abuse
All	Town centers		All
All	Tourist destination		National and State Designated

Broadband Access

Broadband internet can assist in bridging gaps where physical accessibility is insufficient for any or all groups of the population. To work from home, to attend online educational programs, or to use telehealth services may make a place with poor physical access more livable. However, each of these requires broadband internet of a sufficient speed/quality.

TABLE 5: SUGGESTED KEY METRICS FOR BROADBAND ACCESS

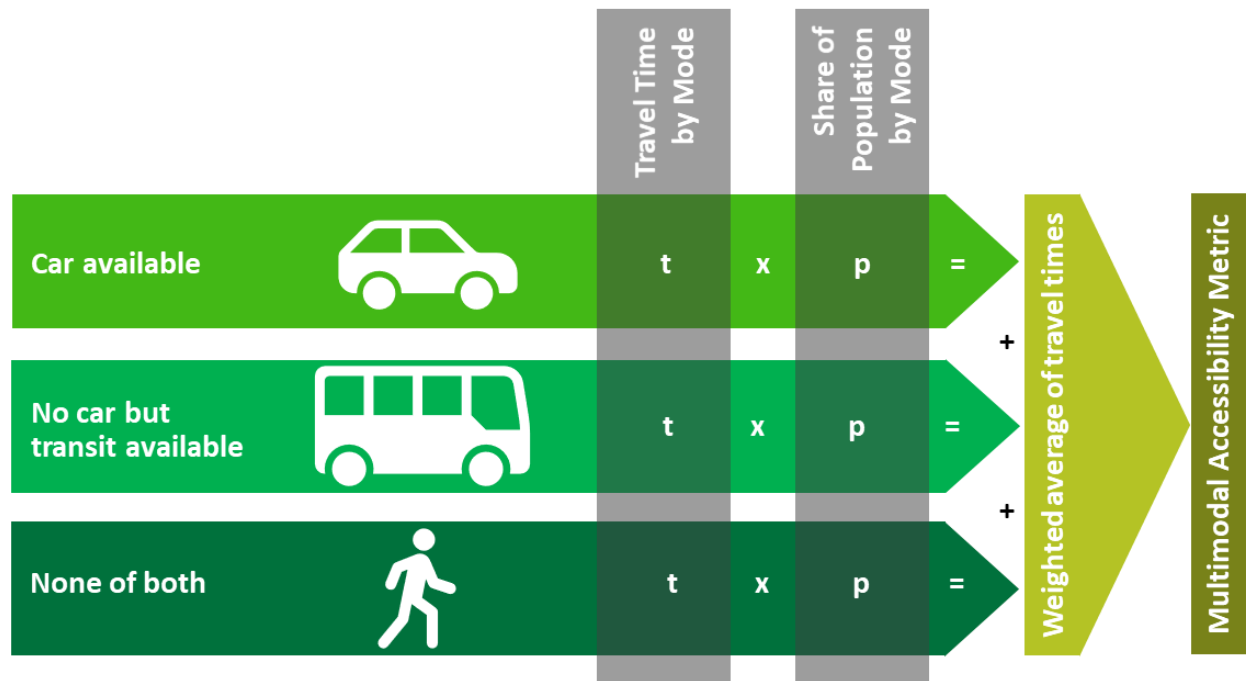
Access to ...	Sufficient Speed/Technology
Mobile Broadband (i.e., cell phones)	LTE
Fixed Broadband (i.e., at home)	≥ 25/3 Mbps download/upload

Multimodal Accessibility

As described above, various user groups and destinations can be differentiated for the purpose of developing a set of metrics that together portray the diverse world of accessibility. Serving the same purpose, various modal options should be also considered. In households with no cars or too few cars, people rely on transit, where available, and other options.

Therefore, multimodal accessibility analysis is important for understanding the influence of car availability on levels of accessibility. Travel times as a measure of impedance may be determined for each passenger mode individually. With information available about the shares of carless and “car-poor” households, and about transit availability within Appalachia, a weighted average of travel times by availability of modal options can be formed and used as a multimodal accessibility metric (Figure 7).

FIGURE 7 COMPOSITION OF A MULTIMODAL METRIC



Developing Accessibility Metrics

How to Get Started

Identifying Methods, Data, and Resources

There is a variety of data for potential use to measure accessibility. The main purpose of this primer is to prompt engagement by transportation decision-makers with accessibility metrics. It is expected that approaches to accessibility measurement will vary across states, MPOs and agencies in the Appalachian Region. Each organization will have their own data, tools, and partners involved in accessibility measurement. This primer's intention is to show how to measure accessibility, recognizing that any given approach may be right for some parts of the Region but not for others.

However, identifying identical data and metrics for the entire Region would provide interesting opportunities to compare accessibility across Appalachia in a consistent manner.

For User Groups

The user group is at the origin from which any accessibility measure is calculated. It includes both the specific constituency for which accessibility is measured and the geographic point that represents where the constituency is located.

The geography can be captured in different ways. The first option is to use a pre-existing zonal system like traffic analysis which are used in travel demand models or census-defined statistical zones. Within each zone, a population-weighted, employment-weighted, or geographic centroid is chosen to represent the zone and to be the starting point of accessibility measurements. A second option is to use a standardized grid system, where accessibility is measured for each cell (e.g., 1 km x 1 km). Each option offers a different scale, leading to a more or less granular description of accessibility.

A third option for geographic definition of origins may be to measure access for each location of interest, e.g., for each business of a certain size. A fourth option is to calculate a level of accessibility for each zone, weighted by measure of the number of affected users, e.g., a policy-targeted measure such as number of people living below the poverty line.

For the Appalachian Region, given its scale and assuming a desire to conduct consistent comparative analysis, using a pre-defined standardized geography may be preferable. Because significant portions of Appalachia are sparsely populated, population or employment affected should be used as a weight. Insufficient access should not be deplored where areas are largely uninhabited. Weighting of user groups may additionally be extended to specific criteria that capture dimensions of economic disadvantage of people or businesses.

For Destinations

There are two fundamentally different approaches to defining destinations in an analysis. The first one is *access to locations where activities happen*, e.g., work (jobs), education, health care, or other services for people, or access to employees, markets, or customers for businesses. Some analyses simply count the number of establishments of a certain type (e.g., schools, restaurants), while others use indicators of magnitude, such as employment or population, to account for the scale of the destination's attractiveness. The second understanding of destinations is *access to important nodes on the transportation network* such as highway interchanges, transit stations, or intermodal freight terminals. Such measures bring attention to the availability of modal options or proxy for the greater levels of access provided by these network "entry points."



Source: ARC

The Appalachian Region with its specific characteristics may call for a selection of destinations based on a hierarchy of need. However, given the sparseness of the transportation network in some parts of Appalachia, measures that focus on network access may also be appropriate. It should be considered that gains in access achieved by projects in the more sparsely populated rural areas can be smaller in magnitude but represent greater proportional gains relative to existing conditions when compared to similar changes in urban areas.

Specific data for user groups and their specific geographic location (origins) as well as for destinations can be found in both the public and private realm. For population and employment, public census data is broadly available with a great level of detail. This gives a lot of flexibility when designing accessibility metrics, because they can be targeted to specific population groups or business industries. However, the use of both geographic and industry detail for employment may require the purchase of proprietary data, which is available from different vendors.

Attributes of Origin / Destination Data

- Geographic resolution of data
- Zonal or point data
- Availability of data
- Public or proprietary data
- Commercially offered or publicly available NGO data

Some data about destinations is collected by non-governmental organizations. This is for example the case for location data for health care providers.

For Network Availability and Conditions

Network availability and performance determines (a) whether access is possible by a given mode, and (b) the “impedance” or effective resistance limiting access between the selected users and destinations of interest. Typical transportation performance variables like travel time, distance, and reliability, as well as direct costs like tolls/fares, determine the barriers to access perceived by travelers. A specific functional form dictates how impedance is quantified in the access measure.

There exist several categories of network data:

- Network data may contain the network topology and characteristics like speed, from which travel times can be determined. Examples of this include OpenStreetMap, the Highway Performance Monitoring System (HPMS), and the Freight Analysis Framework (FAF).
- Other sources contain pre-calculated travel time information, which may be estimated based on network characteristics or actually observed travel times. Examples for the latter include the National Performance Management Research Data Set (NPMRDS), HERE data, TomTom, and Esri StreetMap Premium.
- Routing systems provide a way to find the fastest routes between points and calculate associated travel times. They may be network data agnostic (e.g., Esri’s Network Analyst) or comprise integrated network data and routing systems. Examples for the latter include Esri ArcGIS Online (AGOL) and Google Maps.
- Tools for importing network data into routing systems provide interoperability between routing tools and data sets. For example, there are many ways to process and import OpenStreetMap data into routing systems.

Categories of Network Data and Tools

- Network data (topology and characteristics)
- Pre-calculated travel times
- Routing systems
- Tools to import network data into routing systems
- Non-network transportation nodes and coverage data

- Non-network transportation nodes and coverage data do not allow full network-based routing but contain data on the location of key multimodal transportation nodes or coverage of service. In this category, the National Transportation Atlas Database (NTAD) includes location data for intermodal freight facilities, ports, and airports. The Federal Communications Commission publishes data on fixed broadband and mobile wireless coverage.

Example Implementation

We calculate and map an *access to trauma centers* metric for four counties in West Virginia, according to the following methodology:

User Group: While for certain health care facilities it may seem reasonable to focus on specific age groups, for level 1 and 2 trauma centers all population is seen as the user group. We use census block groups as the geographic units for measurement at users' origin. Access to trauma centers is a population-oriented measure. Therefore, the centroids from which travel times to trauma centers are measured are population-weighted block group centroids, with corrections to geometric centroids as necessary where the population-weighted centroid is located outside of the block group.



Source: ARC

Destinations: Level 1 and 2 trauma centers located within the vicinity of our test area were identified by address, using the American Trauma Society's "Find Your Local Trauma Center" tool.³² These addresses were then geocoded using ArcGIS Online. Only four trauma centers were considered, all of which are situated outside of the study region. A full implementation of this measure would involve mapping other relevant trauma centers as well.

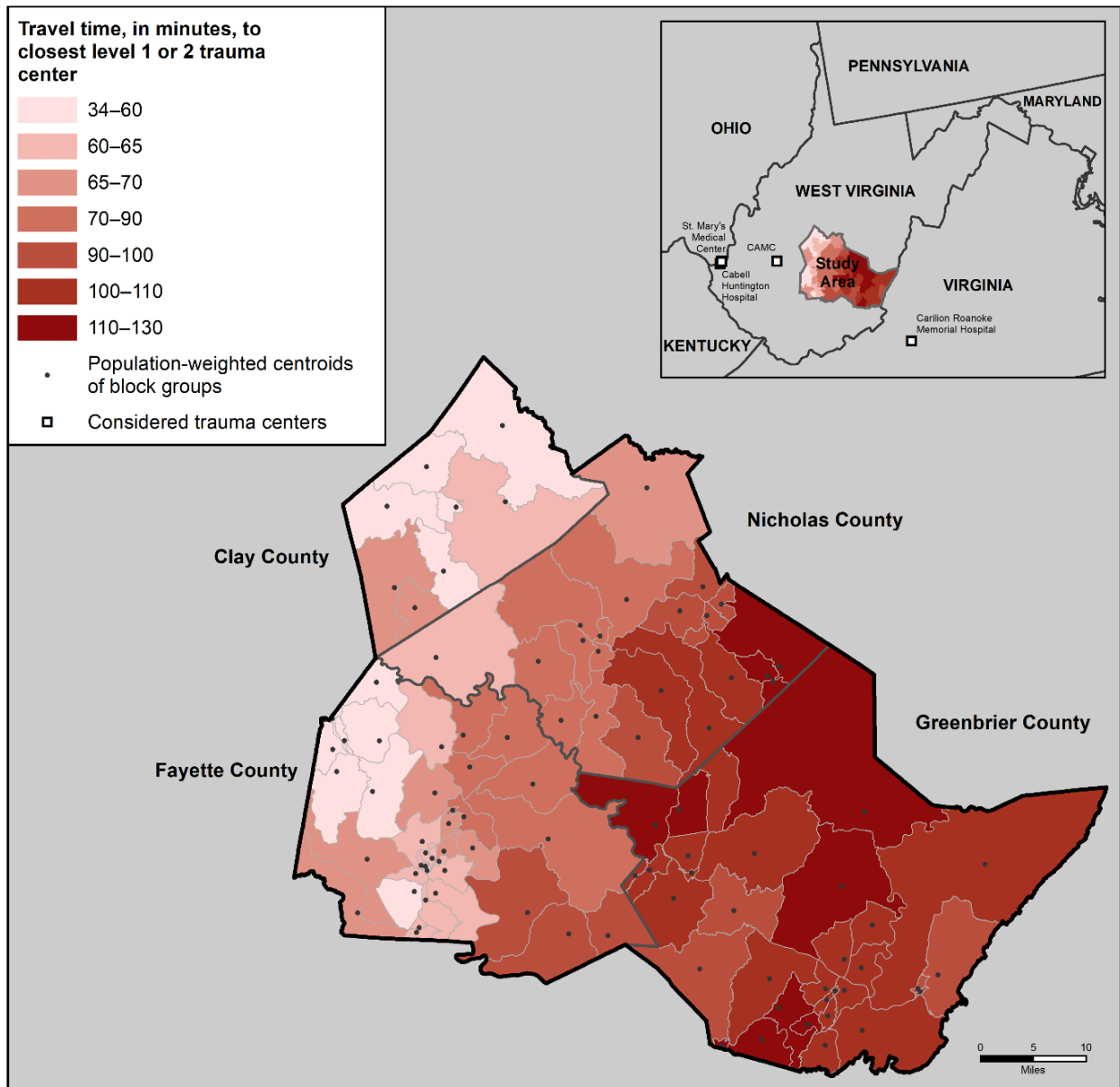
Network/Impedance: Travel times were calculated using the "Find Closest Facilities" tool of ArcGIS Online, calculating car drive times for this metric, without identifying a specific time of day for the calculations.

Results and Recommendations. Figure 8 maps accessibility to the closest trauma center within our test area. As accessibility in this case is not weighted by the importance of the destination or the number of trauma centers within a given

area, accessibility is mapped directly as the travel time. The demonstration illustrates how a

nearest destination metric can be developed and mapped to show where access is more or less constrained.

FIGURE 8 TRAVEL TIME TO THE CLOSEST LEVEL 1 AND 2 TRAUMA CENTER (SAMPLE MAP)



Source: EBP analysis using data from the census, extracted using IPUMS NHGIS, the American Trauma Society, and ArcGIS Online.



Moving Forward

Opportunity

It is now becoming possible to build upon existing information sources and analysis tools to measure and portray levels of access among areas and constituencies. If desired, this can be done in terms of access to jobs, customers, health care, education, and other fields. The resulting insights can be critical in improving various transportation planning and decision processes:

- To improve areawide long-range transportation planning, by identifying areas of greatest accessibility deficiency and need for improvement;
- To improve transportation investment prioritization, by giving weight to projects that address the most critical accessibility improvement needs;
- To improve project planning, by identifying project alternatives that maximize improvement in accessibility and economic opportunity.

There are many ways for regional and state agencies to work together to acquire and apply relevant datasets, develop mutual learning, and share knowledge to apply accessibility measurement methods.

Outlook

ARC's continued mission is to “innovate, partner, and invest to build community capacity and strengthen economic growth in Appalachia.³³” It is in this spirit that ARC has been advocating for issues concerning rural Appalachia. Accessibility has been one of ARC's major concerns when looking at obstacles to economic outcomes.

Through this research and the resulting guidance document, ARC has developed an overview of specific Appalachian needs for access and ways to measure those types of access. In the future, ARC will continue to work collaboratively with and support state and regional partners in identifying access constraints and opportunities for improvements, including possible additional research and development of technical assistance tools.



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