Regional Snapshot Report on Sustainability — DRAFT September 2007

Table of Contents

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1. Introduction

The purpose of this report is to conceptualize *sustainability* in such a way that it can be applied to CMAP's planning and programming activities, chiefly to the Regional Comprehensive Plan, and to develop indicators to determine how well the scenarios developed for the Plan meet sustainability goals. The report represents research and recommendations by staff for consideration by the CMAP Board and CMAP committees. But why adopt sustainability as part of the regional vision and why try to incorporate it into the Regional Comprehensive Plan? At one level, sustainability has found its way into the currency of progressive planning and cannot be ignored, despite the many and perhaps confused meanings attached to it. At another level, we benefit from a fuller consideration of risk, uncertainty, and the end effect of cumulative policy decisions. Finally, while of course not taken up in this report, considering sustainability generates a sense of the connection between the regional vision and the *global vision*, the scale at which the most compelling work on sustainability has been undertaken and where the future presents either a Great Transition toward an imperfect but tenable society or a less pleasant outcome, the decisive factor being choices made now and in the upcoming years.[1]

One of more difficult procedural aspects of using the sustainability concept is its seeming overlap with other norms already in place that go by the name of *good planning*. Planning, especially regional planning, was already expected to address long-term conditions and threats, its aspiration to find policies and projects that satisfy several goals simultaneously, for example in the nexus between environmental protection, economic growth, and quality of life. This is in fact one of the canonical principles of sustainability, as discussed in the next section. This report could therefore take two courses: to try identify *unique* elements or imperatives of the sustainability concept, or to fashion a consensus concept drawn from the sizeable literature on the topic. It attempts to do both. Section 2 quickly summarizes the major conceptions of sustainability and concludes with a set of principles that appear to present a straightforward application to the Regional Comprehensive Plan. There remain some uniquely relevant topics under sustainability that regional planning in northeastern Illinois has never or only in passing addressed, including climate change, resource use and renewability, and adaptive governance. These cross-cutting issues are considered in Section 4. On the whole, this report concentrates on land use and transportation considerations, the core areas which CMAP was formed to address, but tries to avoid prejudging the value of particular strategies. The focus is clarifying the concept of sustainability, demonstrating its importance, and suggesting what a commitment to sustainability on the part of CMAP might entail. It is by no means intended to characterize the "state of sustainability" in the region or to present research on techniques to promote it. Furthermore, the selection of cross-cutting issues is simply a short list of important topics, not a thorough exercise in issue identification.

The use of the term *sustainability* in this report rather than *sustainable development* is deliberate. The National Research Council points out that the latter term usefully calls attention to what is to be sustained (environment) and what is to be developed (community, economy).[2] However, while the term *sustainable development* properly implies that development of some sort is to continue, it appears to be, in this region at least, verbally associated with land development. Thus, some advocates of growth limitation rejoin that "sustainable development is still development" as if sustainable development is a form of greenwashing. It is this interpretation that is avoided by using the term *sustainability*.

2. Concepts of Sustainability

This section very briefly surveys the sustainability literature to select recurring conceptual elements and find a statement of principles that satisfies the breadth of its meaning. The definition of sustainability advanced by the United Nations World Convention on Environment and Development (known as the Brundtland Commission) is the best known and most frequently cited.[3] It focuses on the duty to meet

current needs and to allow future generations, which are not party to current decision making but face its consequences, the opportunity to satisfy their own needs (Table 1). This a statement of intergenerational equity, the fair distribution of benefits and burdens from one generation to another and the preservation of opportunity over time, as well as a recognition of the need to consider a long time horizon for sustainability. From the samples in Table 1, several other repeating elements are apparent: seeking to achieve economic, environmental, and social or equity goals simultaneously (the so-called 3E approach mentioned above); achieving well being, meeting needs, maintaining quality of life, or a similar variation; and maintaining a constant or increasing level of social and environmental goods.

Table 1. Sample definitions of sustainability.

Source	Publication	Definition
Brundtland Commission	Our Common Future	(1) To meet the needs of the present without compromising the ability of future generations to meet their own needs. (2) In essence, *sustainable development* is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations.
NIPC	Building Sustainable Communities	Development is sustainable if it meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable development in action aims to satisfy three guiding principles: economic prosperity, ecological integrity, and community livability. Truly sustainable actions are those that satisfy all three of these principles and enhance rather than deplete the long-term quality of life in our communities.
Asian Development Bank	Online definitions	The assessment that a project's outputs can be produced without permanent and unacceptable change in the natural environment on which it and other economic activities depend, over the life of the project.
President's Council on Sustainable Development	Towards a Sustainable America	Our vision is of a life-sustaining Earth. We are committed to the achievement of a dignified, peaceful, and equitable existence. A sustainable United States will have a growing economy that provides equitable opportunities for satisfying livelihoods and a safe, healthy, high quality of life for current and future generations. Our nation will protect its environment, its natural resource base, and the functions and viability of natural systems on which all life depends.
Olewiler (2002)		Sustainability, broadly defined, is the ability of the economy to maintain the flow of production necessary to ensure non-decreasing per capita consumption indefinitely, so that future generations can have a standard of living equal to or better than that of present generations.
Various	Various	Use or degradation of resources at a rate less than or equal to their replenishment or assimilation rates.
Redefining Progress	Genuine Progress Indicator (2006)	Sustainable development requires a non-declining level of well being for future generations
Daly and Costanza (1996)		The main principle is to limit the human scale to a level which, if not optimal, is at least within the carrying capacity of the remaining natural capital and therefore sustainable.
The Natural Step	http://www.naturalstep.org/com/ What is sustainability/	In a sustainable society, nature is not subject to systematically increasing concentrations of: (1) concentrations of substances extracted from the earth's crust; (2) concentrations of substances produced by society; (3) degradation by physical means; and in that society, people are not subject to conditions that systematically undermine their capacity to meet their needs.

Some definitions, such as that of the Asian Development Bank, offer a much more constrained view of sustainability, limiting consideration to the life of a specific project and adopting a technocratic stance that avoids prejudging the "acceptability" of damage to the environment, implicitly relying on the values

of clients or decision-makers. This seems inappropriate given that sustainability, in the other definitions, seems to carry its own normative force and quantitative target, going beyond permitting acceptable damage to requiring improving or at least non-decreasing conditions. At the same time, the reality of tradeoffs is such that no project could be built were such a criterion strictly applied at the project level instead of to a suite of policies and projects that, overall, improve the regional environment. Other definitions, such as that of Olewiler, employ the language of economists, seeing sustainability as a level of per capita consumption that can be maintained in perpetuity, while others concentrate on achieving *well-being* rather than controlling consumption (Redefining Progress). Other definitions presuppose the purpose of the organization doing the defining. As The Natural Step works with the business community to reduce its environmental impact, often concentrating on manufacturing processes, it is unsurprising to find that its definition leans heavily on the need to control environmental damage caused by resource extraction and industry. This suggests that the definition employed by CMAP should be similarly tailored to its purpose.[4]

There is another approach that assimilates sustainability to the language of economics by differentiating among a number of forms of capital and stipulating that they must be preserved or increased to achieve sustainability. These include human capital, the body of knowledge, skills, and capabilities that can generate services; financial capital, the stock of cash and other forms of money that can be invested to produce a product or increase the amount of financial and other forms of capital; manufactured capital, physical assets produced by transforming natural capital; and finally natural capital, the totality of environmentally-provided assets, including renewable and non-renewable resources.[5] Capital represents accumulated wealth, and under this concept of sustainability the notion of wealth is simply broadened beyond financial wealth. This way of looking at sustainability reflects the often-heard, common sense idea — typically with regard to natural resources — that a society should "live off interest rather than principal."

Clearly there is a variety of ways to conceptualize sustainability, but they can be divided roughly into three classes: definitions based on the 3E model, the Brundtland approach (allowing future generations to meet their own needs), or the capital preservation model. All three offer complementary and independently important emphases, and so it is recommended that CMAP try to combine them. As two further conditions on selection, the definition or concept chosen should be drawn from the literature rather than created new, and should lend itself to the mission of the agency, i.e., integrated regional land use and transportation planning. These conditions suggest the principles in Table 2.

Table 2. Recommended CMAP principles of sustainability.

Future Conditions (F)	Present Conditions (P)
1. Protect environment and improve natural resources for future generations.	1. Improve economic performance and quality of life for individuals.
2. Preserve the value of human and man-made capital for future generations.	2. Ensure a fair distribution of life-quality.

Source: Modified from Gudmundsson H. and M. Hojer. 1996. Sustainable Development Principles and their Implications for Transport. *Ecological Economics* 19(3): 269–282.

It can be seen that the recommended principles incorporate each of the three concepts of sustainability discussed above. Economy, environment, and social equity are captured by P1, F1, and P2, respectively. Principle P1 captures the need for improving economic growth, while F1 requires a non-decreasing stock of natural resources and P2 requires an equitable distribution of the goods to be considered in the Regional Comprehensive Plan. Meeting all principles simultaneously would satisfy the 3E definition of

sustainability. Protecting the ability of future generations to meet their own needs through present stewardship is captured in F1 and F2. Preserving and increasing the four forms of capital is likewise captured: financial in P1, natural in F1, manufactured in F2, and human in F2.

3. Application to the Regional Comprehensive Plan

The Regional Comprehensive Plan will utilize scenario modeling to compare alternative futures against the regional vision, select a preferred scenario that best meets the vision, and recommend policies and major capital investments to implement the scenario. In order to address sustainability adequately, the sum of the actions recommended in the Regional Comprehensive Plan would need to help accomplish the elements of the matrix of principles in Table 2. This section recommends ways of operationalizing each of the principles — meaning that the principles are interpreted further and applied within the ambit of the Regional Comprehensive Plan — and concludes with a summary of the indicators recommended to judge the scenarios' attainment of the sustainability principles (Table 4). It must be emphasized that, for use in scenario planning, each indicator must be *projected* into a possible future, as opposed to tracked over time, and must be responsive to regional modeling. This significantly limits the number of available indicators. However, a proposal is advanced in Section 3.5 to track a larger number of indicators over time, partly as a means of monitoring implementation of the Regional Comprehensive Plan.

Table 3. Selection criteria for indicators.

Criterion	Explanation
Projectability	Reliable data and acceptable projection methodology must be available
Understandability	Should be comprehensible to lay stakeholders
Policy relevance	Should reflect Regional Comprehensive Plan's core areas of influence
Responsiveness	Should be a potential regional model output and responsive to scenario changes

Source: Modified from Kutzmark, T. 2004. *Community Indicators: Integrating Science and Local Knowledge in Monitoring Programs* (Masters Thesis, University of Washington).

The indicators were selected by applying a set of basic screening criteria, as described in Table 3, to a longer list of candidates categorized under each sustainability principle. In addition, a distinction was made between types of potential indicators. A relative indicator is meant to compare the performance of two or more scenarios without specifying a particular standard of achievement. A threshold, on the other hand, is an absolute indicator that compares scenario performance against a critical level above or below which some effect occurs or does not occur. Finally, a target is a standard of achievement set with regard to practical considerations or stakeholder values rather than to a critical level.[6] With some exceptions, most of the recommended indicators are relative.

3.1 Principle F1

3.1.1 Regional Carrying Capacity

The ideal limit on natural resource use would be *carrying capacity*. This is a concept that appears in the sample definitions, arising originally from the literature on population dynamics, that postulates a threshold of resource use and environmental damage in an area beyond which ecological integrity is impaired. It receives a clear exposition as a central tenet of sustainability by the ecological economists Robert Costanza and Herman Daly, who write that "the main principle is to limit the human scale to a level which, if not optimal, is at least within the carrying capacity of the remaining natural capital and therefore sustainable."[7] In practice, the concept has most often been applied in studies of agricultural or extractive economies, generally in the developing world, but also in regional planning such as that the Ministry of Environment and Forests in New Delhi undertakes.[8] It has also been applied in a regional

planning context in the U.S. by the South Florida Regional Planning Council in the *Florida Keys Carrying Capacity Study*.[9] For the purposes of the CMAP Regional Comprehensive Plan, however, it is doubtful that regional carrying capacity can play a useful role. Spillover effects beyond the region are extensive, both in terms of resource use and impact on natural resources, making the notion of *regional* carrying capacity intractable. For instance, supply chains for manufacturing firms in the Chicago area extend around the globe, meaning that the postulated ecological limits on, e.g., bauxite mining in Australia have been appended to those of Everett, WA, where Boeing airplanes are built, and then appended to the Chicago area, where Boeing's headquarters are located. While the condition that the Chicago area relies on external sources for food products, industrial materials, etc., especially when they cannot be sourced here, could be interpreted to mean that the Chicago region has exceeded its regional carrying capacity, it is unrealistic to suppose that trade will be limited to a significant extent. Indeed, Chicago largely owes its existence to such trade.[10]

The other side of regional carrying capacity, damage to regional natural resources, is conceptually more tractable, yet remains difficult to measure in a comprehensive fashion. The experience of the South Florida Regional Planning Council with the *Florida Keys Carrying Capacity Study* is instructive with regard to the practical difficulties involved. According to the Florida Administrative Commission ruling that required it, the study was "to determine the ability of the Florida Keys ecosystem… to withstand all impacts of additional land development activities."[11] Thus, as implied by the term carrying capacity, the study had to establish thresholds for ecosystem stressors. The study included development of a model with modules covering fiscal impacts, water quality and the marine environment, "human infrastructure," quality of life, and habitat. The National Academy of Sciences was asked to review the results and ultimately concluded in 2002 that "the current knowledge base in the environmental and social sciences is simply not yet adequate to enable anyone to 'determine the ability of the Florida Keys ecosystem to withstand all impacts of additional land development activities.' That knowledge cannot be ordered up no matter how badly it is needed or desired."[12] In general, there are no established legal limits or well defined stress-response thresholds for habitat degradation, solid waste generation, and a number of other ultimately destructive activities. In *Our Common Journey*, the National Research Council expresses similar sentiments about the attractiveness of the concept but skepticism about its use.[13]

Instead of regional carrying capacity, it may be best to consider a regional share of a global carrying capacity. This has been operationalized in Ecological Footprint (EF) methodologies that attempt to estimate the amount of resources needed to support a population and an economy and convert the sum into a unit of land area per person.[14] Considering the global interconnections in resource use, this should be carried out using worldwide figures. No examples have been found of other scenario modeling exercises using the EF as an indicator, but since different regions have been compared using a common EF indicator,[15] it stands to reason that different scenarios for the same region could be compared.

3.1.2 Water Quality

The foregoing is not to say that more limited or sector-specific carrying capacity approaches to natural resource impacts are unworkable. Water quality is a good example. For instance, the Total Maximum Daily Load (TMDL) program under the Clean Water Act determines the total pollutant load that a water body can sustain while still meeting water quality standards for specific pollutants.[16] The standards themselves are to be set by states — in Illinois, by the Illinois Pollution Control Board — to protect designated uses of water bodies. If the standards do in fact fall within carrying capacity, then a TMDL meeting the standards would also fall within carrying capacity. Such a detailed level of analysis would be impossible for the Regional Comprehensive Plan, however. As a minimum proxy, it is recommended that

the Plan consider as an indicator the creation of new impervious area by land development. This indicator relates land use change to declines in water quality from non-point source pollution and does have a well-established (but rule-of-thumb) threshold. It is generally accepted that water quality tends to decline after 10 percent of a watershed is impervious,[17] although some effects can be mitigated by adequate implementation of best management practices. It may be possible to incorporate a fuller treatment of water quality, as well as rate and volume of runoff, into the regional land use model, thus making it possible to estimate the beneficial effects of policies such as watershed development ordinances. The root of the problem, however, is ground surface hardening, an issue best addressed through land use controls, including adjustment of required parking ratios in zoning codes, density and open space preservation, improved site planning standards, etc. Optimal pricing of parking facilities could also control imperviousness, among many other means.[18] Imperviousness can readily be projected for the unit of analysis in the regional land use model via assumptions about lot coverage for different land uses and then aggregated to watersheds, the preferred level of detail being Hydrologic Unit Code 10.

3.1.3 Air Quality

Like water quality, air quality has standards established by regulatory agencies, in this case the U.S. Environmental Protection Agency. Unlike water quality, CMAP is required to show that its transportation plan recommendations meet the air quality standards. The conformity analysis CMAP will prepare documents that mobile source emissions of volatile organic compounds and nitrogen oxides (precursors of ozone) and fine particulate matter under the adopted plan fall within the limits required for achieving clean air standards.[19] Returning again to the carrying capacity discussion above, if those limits are within carrying capacity for the relevant air pollutants, then the adopted plan would be as well. But while the conformity requirements mark an important step forward in federal program integration, they are not expected to shape the Regional Comprehensive Plan significantly because federal standards for engines and fuels have an overwhelming impact on vehicle emissions. In short, ensuring conformity requires only a limited range of possible air quality-related actions that would improve public health and environmental quality. In addition, air quality standards are established only for the six "criteria" pollutants under the Clean Air Act, and so the regional planning agencies have not historically modeled or addressed other air pollutants. Since land use plans are not required to address air quality, regional planning agencies have not sought opportunities to leverage other emissions reductions programs, e.g., for area-wide sources; nor has regional planning addressed emissions from point sources. Furthermore, greenhouse gas emissions are not currently regulated under the Clean Air Act. These are a longer-term threat that the Regional Comprehensive Plan should seek to minimize, as discussed in Section 4.2. It is clear that a more robust approach to air emissions would carry the region closer to meeting the sustainability principles. In fact, because of its effects on both environmental quality and public health, as well as its distributional aspect, air quality cuts across the sustainability principles. No specific indicator(s) for air quality are being recommended in this report, as another regional snapshot report is expected to address air quality and to seek innovative ways to improve it; however, it is recommended that scenario modeling include indicators of air quality improvement beyond the requirements of conformity analysis.

3.1.4 Natural Resource Damage

Beyond water and air quality, the Regional Comprehensive Plan should include assessments by scenario of natural resource damage. Past regional impact assessments have done this in two ways. For the *2030 RTP* NIPC produced an assessment of transportation project proposals and alternative regional scenarios by assigning weights to seven natural resource layers in a GIS model, then computing a total impact score

by overlaying the projects on the resource layers within a 2.5 kilometer buffer.[20] The virtue of this approach is that it takes some account of natural resource quality, but its downsides include the subjective assignment of weights, especially with the total score depending heavily on the weights chosen, the undefined nature of an "impact," and the arbitrary choice of a buffer width. The use of such weighting essentially attributes greater importance to one type of resource versus another, e.g., wetlands versus shallow aquifers. For the McHenry County Local Legacy project, on the other hand, the Land Use Evolution and Impact Assessment model (LEAM) was used to project actual destruction of certain landscape features, such as forest and wetlands, given various infrastructure investment and growth scenarios.[21] It also produced estimates of "pressure" on threatened and endangered species and various ecosystem components, but did not develop a single impact score. The pressure indicator essentially showed the probability of development in a given area containing important natural resources. Significantly, the LEAM assessment did not take into account resource quality, only quantity and location.

The most important difference between the two approaches, however, is that LEAM projected natural resource damage based primarily on development induced by transportation projects, whereas NIPC confined its attention to the direct and indirect effects of the projects themselves, a land use model lacking at the time. It is expected that the induced effects of transportation projects would outstrip the damage caused by the projects themselves, both during and after construction, although direct effects could be significant as well. Thus, for the Comprehensive Plan, the comparison of environmental impacts should be carried out primarily at the scenario level, rather than at the level of individual projects, so that policies to limit natural resource damage from induced development can have some effect. Damage should be projected, as far as possible, in units of acres, stream miles, etc. affected, as this would be expected to be more resonant for stakeholders than a single index score. The "pressure" indicator used by LEAM also seems to be more intuitive and robust than an index score. Finally, while the buffer in the NIPC model was arbitrary, in remains important to incorporate an impact radius of some sort, at least for evaluating transportation project impacts.

Finally, Principle F1 requires the natural resource base to be improved for future generations. Because regional development will inevitably cause localized natural resource damage, the Regional Comprehensive Plan should include ecosystem restoration to offset, or more than offset, that damage if it is to satisfy Principle F1. This raises the question of how to compare damages and offsets, as well as how to target restoration. While more study is clearly required, one approach might be acre for acre compensation (or greater) across all community types, so that restoration of one acre or more of floodplain forest compensates the destruction of one acre of savannah, which could be accomplished through fees-in-lieu or set-asides or another mechanism. Another might be based on a comparison of monetized ecosystem services, although this approach would require intensive special study and may be unable to render satisfactory results because of methodological problems. A number of other offset systems are possible, however, and it is recommended that a methodology be developed as part of the lead-up to scenario analysis.

3.1.5 Habitat Fragmentation

The attempt to prevent declines in the quality of natural resources is also an attempt to preserve biodiversity, the "totality of genes, species, and ecosystems in a region," according to the Chicago Wilderness *Biodiversity Recovery Plan*.[22] But the most significant threat to biodiversity recognized by most researchers is habitat fragmentation — that is, not just the destruction of specific ecosystem types, but their disconnection from one another.[23] The Regional Comprehensive Plan should include an indicator of

habitat fragmentation as part of meeting Principle F1. More research will be done on the issue as part of the strategy analysis, so the recommended indicator is a placeholder at this time.

3.2 Principle P1

Principle P1 has two main components, improved economic performance and quality of life, where the engines of wealth in the region are stimulated and harnessed to improve individual lives. In other words, this principle expresses the need for economic development, as commonly and correctly differentiated from pure economic growth, i.e., increase in output. While economic development can have many meanings, it entails creating jobs and increasing income for individuals and households, at the very least, as part of quality of life.[24] Like the term *sustainable development*, economic development frequently is conflated with real estate development, but this is not what is meant by the term in this report.

3.2.1 Transportation Infrastructure and Economic Development

The economy is transport intensive and becoming more so. This is revealed most obviously in the close relationship between ton-miles of freight transport and GDP,[25] but also in the way the advent of manufacture-to-order logistics or just-in-time shipping has reduced the costs of maintaining inventories while increasing reliance on timely goods movement.[26] Freight is particularly important to the Chicago region, even given its diversified economy, the Chicago region being the top freight hub among metropolitan areas in the U.S.[27] In turn, supporting the economy has long been an explicit part of regional transportation planning in the Chicago area, as in the CATS *2030 Regional Transportation Plan*'s statement of intent to "promote an efficient urban economy and sustain it,"[28] as well as a component of the NIPC *2040 Regional Framework Plan*'s theme of regional competitiveness.

The question for this section is how the Regional Comprehensive Plan can achieve Principle P1 while also respecting the other principles. To begin, the recommendations for major capital investments developed for the Plan clearly will have economic effects. There are three general categories of economic benefit from transportation investment: employment supported by construction, direct user benefits, and improved industry productivity, i.e., reduced production costs per unit output.[29] Studies generally show a significant relationship between transportation investment and various measures of economic benefit,[30] but industry productivity is arguably most important to long-term economic performance, especially if productivity is taken as the sign of regional competitiveness, as it frequently is.[31] Then how does transportation infrastructure investment affect industry productivity? Research findings are somewhat ambiguous, but the prevailing view appears to be that transportation capital investment has a positive effect on productivity and output, while the magnitude of the effect on a nationwide basis is variable and generally weak.[32] For example, FHWA-sponsored research found that, over the period 1950–1991, returns to highway capital in the form of increased industry productivity were $0.18–0.30 per dollar of highway investment.[33] While the positive effect of transportation investment on productivity and growth may seem exceedingly obvious, such research has been undertaken to test the countervailing idea from economic theory that public investment tends to "crowd out" private capital. The weak nationwide effects, however, say nothing about local, project-specific benefits, which can be quite high, especially since productivity benefits accrue more to industries where transportation is a relatively large factor of production. The Chicago region is specialized in a number of these industries.

FHWA research indicates that the nationwide return to highway investment has declined substantially since the post-war interstate construction era. [34] This is probably true of investments in other modes as well. At least two explanations can be advanced for this. One is that assets have been maintained at a lower level than needed, so that returns have fallen over time,[35] pointing to the need to address system

maintenance as required by Principle F2. Another explanation is simply that the highway system is so extensive at this point that the marginal benefit to industry of further investment has declined. Either way, this suggests the Regional Comprehensive Plan should also investigate non-capital intensive means of achieving productivity gains, especially techniques that "decouple" economic improvement from overall traffic growth.

Transportation and other infrastructure provides economic benefits to commerce, but private business is not the direct beneficiary, some special cases aside. Benefits are diffuse, and welfare gains for passenger traffic predominate. Pure economic development strategies, on the other hand, are more targeted, and either provide assistance to private business or to individuals, which then generates positive spillover effects — job creation and income increases among them — to a wider group of beneficiaries. They hold the potential, if handled creatively and collaboratively, to improve economic performance and support job creation and income growth directly. If the Regional Comprehensive Plan is to address P1 adequately, it should take such a direct approach, going beyond (but including) transportation-focused strategies. The direct effect of infrastructure recommendations on economic performance remains important, however, and should be assessed and should be linked to fundamental economic development objectives.

One way of doing this is as follows. It is expected that research by CMAP and partners will identify target industries and occupations as part of comprehensive plan development. Among the various factors involved in such an analysis, prospects for employment and wage growth should be included, as they relate to fundamental economic development objectives. A fuller evaluation of sustainability impact would assess industries on a wider range of metrics, including energy and resource consumption and so forth, but the point is specifically to examine the effect of major capital investments on target industries and occupations. The measurement of productivity, wage growth, and employment growth discussed below should be stratified by target industry.

3.2.2 Productivity and Sustainability

How to value economic growth is probably the central question of sustainability for industrialized nations. Increasing output drives much resource depletion worldwide, as well as generating wastes beyond the capacity of the immediate environment to assimilate, some toxic to humans, and arguably diminishes quality of life in less developed countries serving final demand in the industrialized world. It is difficult to define and measure economic sustainability on the scale of a region small relative to the planet, as hinted in Section 3.1.1. Part of the background concept of sustainability, though, is efficiency, in the sense of doing more with less; for example, as one of his central principles Herman Daly notes that "sustainable development should be efficiency-increasing rather than throughput-increasing."[36] The concern here is with productivity rather than growth, using fewer inputs per unit output rather than maximizing output. Elsewhere it has been suggested that (labor) productivity and employment expansion could be used in combination as crude indicators of economic and social sustainability.[37] For the overall economic performance of the region, then, it is recommended that the Regional Comprehensive Plan employ total factor productivity — the portion of output growth not accounted for by increased inputs of capital, labor, and materials — as an indicator. Economic models, such as REMI Policy Insight or IMPLAN, are typically able to project these quantities in response to scenario changes.

Part of the attractiveness of focusing on productivity is its equation, as noted above, with regional competitiveness. This in turn implies a commitment to "high road" economic development, where regions and firms compete on the basis of technological innovation and steady employee skill upgrades, rather than "low road" competition on the basis of low-wage labor,[38] and reveals the importance of

investment in human infrastructure as called for in Principle F2. Increasing productivity has sometimes been seen as a bugbear in regional economies such as Chicago's that were once driven by manufacturing, as it can lead to job loss, but there are many other reasons behind deindustrialization. Taking the high road of workforce investment is meant to counteract this tendency. The overall sustainability indicators for Principle P1 include total factor productivity, wage growth, and employment growth. These should be stratified by target industry if possible, as discussed above.

As an indicator of output, gross regional product (GRP) should be included, despite its various problems. These include the inability of the indicator to capture non-market values such as housework, its inclusion of outputs that are *social costs*, such as spending on health care stemming from vehicle collisions, and its lack of adjustment for declining natural capital stocks.[39] A number of alternate indicators are available from different researchers, but they have proven difficult to use, especially in the context of generating scenario-based projections.[40]

3.2.3 Local Government Finance and Economic Development

Economic development activities are widespread in the region, most of them local and carried out by municipalities. Visiting the website of any chosen village in the region generally reveals information on economic development programming displayed prominently. A study in the Minneapolis area found that 86 percent of municipalities undertook formal economic development efforts; those that did not were typically small, under 10,000 in population.[41] What motivates these efforts? By one line of thinking, the *fiscal imperative* drives them, caused by conditions in which municipalities perceive a need to attract highly mobile private capital, the industrial and commercial operations thought to contribute more in taxes than they require in services.[42] In a metropolitan area with many local governments, as in the Chicago region, this situation creates a "government marketplace" in which jurisdictions stand in competition with one another for economic activity, frequently employing various incentives to attract businesses — infrastructure or land contributions, bond financing, tax abatement, etc. — that act as subsidies to firms.[43] If a firm approaches more than one municipality with a development proposal, it may be able to bid up the value of incentive packages. Unfortunately, local government officials are at a fundamental disadvantage in these negotiations because representatives of the firm can be presumed to know the minimum acceptable incentive package, whereas a municipality cannot. Similarly, incentives may also be directed to a firm even if it would have chosen to invest in a particular location regardless of the subsidy. These conditions can produce a so-called corporate surplus.[44] Furthermore, it is difficult for local governments to attach conditions to incentive packages so that the incentives are returned if the firm relocates or closes its doors.

This form of interlocal competition ensures that there will be at least one, and probably more than one, loser for every winning jurisdiction, while likely resulting in the wasteful expenditure of funds. Furthermore, such fiscal competition may not relate clearly to the fundamental economic development objectives of creating jobs and raising income. If competing locations are within reasonable commuting distances of one another — most municipalities consider neighboring municipalities their closest competitors[45] — the income and job creation benefits would generally accrue to residents of either place. In this context, it can be seen that these economic development objectives are essentially regional in nature, whereas fiscal considerations are not. Given the dependence of local governments on local taxes, however, improving local government revenue collection remains crucial. The Regional Comprehensive Plan should therefore include economic development strategies that benefit the residents of a group of municipalities or the region as a whole as well as developing a scenario in which fiscal benefits can accrue more evenly to jurisdictions ordinarily in competition.

It is still important, given local government reliance on property and sales taxes, to increase their tax bases. Principle P2 provides guidance on the distribution of that base, but P1 calls for its aggregate increase. For the taxing districts in the region, the most relevant indicator is the expected change in the *tax capacity*, the total equalized assessed value and taxable sales in the metropolitan area. This is the expected "public wealth" of the region, translating into the ability to provide public services and comprising part of quality of life.

3.2.4 Quality of Life

Regional modeling cannot attempt to yield a complete depiction of quality of life, as this varies with factors — educational attainment, family life, crime rates, perceptions of social opportunity, etc. — that are well beyond the *immediate* influence of the Regional Comprehensive Plan and are not readily "modelable." It is proposed that the Regional Comprehensive Plan address this difficulty in two main ways. First, a number of quantifiable factors can be assessed that clearly contribute to, but do not exhaustively capture, quality of life. Among these are overall trip length (under the assumption that people prefer to minimize time and distance of travel), hours of delay, and accessibility of jobs and transit. Second, it is recommended that a qualitative description of expected quality of life benefits be provided to accompany scenario modeling to meet the need to operationalize P1. One option is to develop narratives that evenhandedly describe what representative individuals' lives might be like were a given scenario realized.[46] Finally, although quality of life will not be a regional model output as such — but will, again, be partly addressed through a subset of indicators — this does not mean that quality of life cannot be unpacked into a larger group of indicators for longer-term tracking. A proposal to do so is advanced in Section 3.5.

3.3 Principle F2

It is expected that the chief form of manufactured capital that the Regional Comprehensive Plan will be concerned with is the existing and planned transportation system, although building stock and utility infrastructure also come into play. Principle F2 means that future generations must be given the opportunity to benefit from the existing transportation system, and so requires that current decisions contribute to the system's future usability. In other words, the *option value* of the transportation system should be preserved. It might also be argued, however, that "we may just as well fear that the propensity for transport systems to become increasingly large, long lived and pervasive will force society still deeper into a [trap] of mobility … [so that] investing heavily to reinforce existing transport systems may in the end prove to be a highly costly and even socially destructive way of safeguarding access for future generations to what they want or need."[47] Because of this condition, the future value of a transport facility could be less than it is today, even if maintained in a good state of repair, because it may not fit the needs of future generations.

The decision whether to emphasize transportation system expansion or system maintenance returns perennially in every plan cycle.[48] It is clear, however, that with the extensive catalog of highways and rail lines in the region at present, system maintenance will take the lion's share of the limited projected funding — about 75 percent in the *2030 Regional Transportation Plan*, and almost all in the Regional Comprehensive Plan if no additional funds are developed — so Principle F2 is nearly moot at the overall system level. An answer to the dilemma posed above requires a more incisive look at specific project proposals, but, in general, it is recommended that the Regional Comprehensive Plan develop a scenario prioritizing the maintenance of elements of the transportation system expected to be of highest benefit to future generations. Few generalizations can be made in this regard, but difficult tradeoffs could arise. For

example, if fossil fuel costs continue to climb or greenhouse gas emission reductions gain in urgency, as is likely, transit infrastructure and the denser development patterns it can support should rise further in importance, as should the need to commit funds to its preservation. Now, should a stark maintenance tradeoff between roads and transit actually arise, prioritizing transit for its future benefits would probably exact a larger toll on current drivers than the opposite priority would exact on transit users since there are many more drivers, damage to automobiles could be expected, freight transport would be hindered, and so on.

Regardless of the solution to this apparent system preservation dilemma, indicators of system maintenance levels should be used to evaluate projected transportation asset conditions as part of the Regional Comprehensive Plan. The recommended indicators are the number of miles of roadway in disrepair, number of bridges in disrepair, and the condition of transit assets.[49] Again, the proposed indicators should be used in a relative sense to compare different scenarios against one another rather than a target. These indicators track only facility conditions rather than "true" sustainability — their contribution to the overall sustainability of the urban environment, as measured by the other indicators. In other words, reinvestment in facilities that perpetuate a "mobility trap" may preserve those facilities but not tend to promote overall sustainability. The long-run solution to the dilemma posed above lies in the future value of investment in infrastructure expansion and its ability to promote efficient urban form. Transportation facilities, sewer lines, water mains, and land use decisions such as subdivision layouts will be with us for decades. It can be expected that future generations will benefit from more compact development patterns, and so the Regional Comprehensive Plan should focus closely on the variety of strategies for promoting efficient urban form.

One additional way of taking system preservation into account in the Regional Comprehensive Plan is the use of life cycle costing, a technique that explicitly compares the costs of building and maintaining the functionality of alternative facilities over their entire design lives.[50] For instance, a decision might be made to construct a highway with the knowledge that additional lane capacity would eventually be needed but without taking into initial consideration the future travel time and accident costs of the work zones necessary to add the capacity. Life cycle analysis would include such costs in the total cost of the project from the outset. Its application to system preservation would render the future maintenance costs of different design alternatives more evident and perhaps help ensure that present cost reducing designs do not unfairly raise future costs. It is recommended that the cost estimates developed for major capital investments in the Regional Comprehensive Plan use life cycle cost analysis techniques. Ideally life cycle costing could also be applied to investments in alternative modes, e.g., a road project versus a rail project. Although this may not be possible, since the analysis is meant to apply only to projects (design alternatives) with equivalent benefits or levels of service but differing costs,[51] it should be investigated further in the lead-up to plan development.

The other imperative of Principle F2, the preservation of human capital, may be addressed as the quality of life factors are. While education, job training, and other aspects of people-based economic development may be part of the Regional Comprehensive Plan, it is best to track these as a means of monitoring plan implementation over a longer time frame. They should be part of the proposal discussed in Section 3.5.

3.4 Principle P2

In seeking to attain sustainability, the most appropriate position from which to judge the distribution of the goods of society, which together add up to quality of life, is that of the most disadvantaged stratum of society. An equitable decision will improve the prospects of the most disadvantaged, although others are

expected to benefit as well. This conception of equity is due to John Rawls, as interpreted by Hall,[52] and is sometimes called *vertical equity* to contrast it with *horizontal equity*, the fairness standard of treating similar people similarly or fairly sharing benefits and burdens. In comparing scenarios or projects, these two conceptions of equity will unavoidably mingle.

Previous efforts by CATS have attempted to judge the effects of transportation scenarios on disadvantaged populations by stratifying projected level of service according to household income and the proportion of minorities in each transportation analysis zone.[53] Level of service in this case means the availability of transportation modes, access to transit, access to jobs, and commute times. Thus, the effects on travel time, transit access, etc. caused by emphasizing system expansion or increased service or one of the other two scenarios could be evaluated for low income and high minority areas. Equity effects were compared between scenarios rather than against a standard. As is evident from the discussion in Section 3.2, the level of service metrics used in the *2030 RTP* are the sort of quality of life indicators that can be treated quantitatively in the Regional Comprehensive Plan. Therefore, as Principle P2 requires an equitable distribution of quality of life, and this is evaluated by a scenario's positive effects on the least advantaged segments of society, the procedure used in the *2030 RTP* would partly measure Principle P2. A sustainable scenario, using these indicators, would increase the availability of transportation modes, increase access to transit and jobs, and decrease travel time for the most disadvantaged strata of society. The *2030 RTP* also measured geographic equity. While this is important, it would appear to relate more to horizontal equity. Although disadvantaged status and geography are correlated, as long as the Regional Comprehensive Plan assesses the positive or negative effect of transportation investments on the *population* of a given geography, it will evaluate the central sustainability question of whether planning decisions are improving the lives of the least advantaged persons.

Equity in the Regional Comprehensive Plan cannot be restricted to transportation-related effects; a broader and deeper view of the distribution of life chances is needed if an ambitious regional vision is to be realized. With this in mind, the spread in regional prosperity is the highest and best indicator of equity, as it arguably affects the ability to achieve goals more than any other factor. It is recommended, then, that the Regional Comprehensive Plan include an indicator that characterizes the equality of the income distribution among households. The most widely used and understood indicator is the Gini index, which varies between 0 and 1 and measures how close an income distribution is to perfect equality (0 = perfect equality; 1 = perfect inequality). It is proposed that the Regional Comprehensive Plan utilize the Gini index or similar for evaluating the projected income distribution by scenario, where again the purpose is a relative comparison.

Households are not the only relevant units, however. The fiscal health of municipal government is a strong determinant of its ability to meet the needs of citizens through public service provision (and thus also contributes to quality of life). While "fiscal health" is vague and may be affected by a wide range of factors, it is recommended that the equalized assessed value of property within municipalities be used as the chief indicator, as it represents the base on which local government services stand. The Gini index can be modified to provide a measure of equality of per-capita equalized assessed value between municipalities rather than equality of income between households. As noted above, the equity element of sustainability requires that decisions improve conditions for the least well-off households or municipalities, i.e., encourage a more equal distribution of wealth.

3.5 Summary of Proposed Indicators

The sections above discussed both the recommended interpretation of the sustainability principles and the proposed indicators for judging the performance of the Regional Comprehensive Plan scenarios. Table 4 below summarizes these indicators. While a number of relevant metrics will not be regional model outputs as such — such as broader quality of life metrics under P1 and human capital under F2 — this does not mean that they cannot be unpacked into a larger group of metrics for longer-term tracking. It is recommended that CMAP, in concert with external partners, develop a suite of regional indicators that capture quality of life and other aspects of sustainability as a time series in order to track the progress of the region. There are many examples of such indicator projects in the U.S., starting with Quality Indicators for Progress in Jacksonville, FL in 1983.[54] Will County Center for Economic Development has been tracking quality of life indicators, explicitly tying them to economic development, and could serve as an excellent model.[55] One of the best of the recent regional efforts is the Boston Indicators Project, a comprehensive indicator initiative for the Boston metro area with a well-developed web interface.[56] Producing a such a web-based suite of indicators for northeastern Illinois would bring CMAP closer to implementing its core function, as identified in the *Strategic Report*,[57] of providing information and analysis to the region's citizens and decision-makers, and in the most accessible possible format. It could also make excellent use of CMAP's stage-setting in the creation of the Illinois Data Exchange Affiliates (IDEA), an initiative that promotes partnerships among agencies to provide real-time, continuously updated data over the Internet. Finally, while such a project would not, strictly speaking, be an element of the Regional Comprehensive Plan, regional indicators can be seen as a way of monitoring plan implementation, tracking how closely the reality of the region comes to match the vision.

Although the *2030 RTP* did not officially select a preferred scenario, the Regional Comprehensive Plan is expected to do so, leading to the question of how to deal with tradeoffs among Sustainability Principles F1 – P2. As the background 3E definition of sustainability suggests, the separate components of sustainability should be treated more or less equally, but tradeoffs are unavoidably involved both between principles (e.g., a scenario scoring well on F1 may do poorly on P2) and within a principle (e.g., a policy may have disparate impacts but be included within a scenario that has the best overall equity score). Clearly there is no way to lay out a decision rule for tradeoffs in advance, but essentially a sustainable scenario will have each indicator showing no change or an improvement relative to the baseline scenario.

Table 4. Summary of potential sustainability indicators for scenario modeling in the Regional Comprehensive Plan.

Principle	Indicator	Units	Brief Rationale	Section	Type	Direction
F1	Ground surface hardening	Percent impervious by watershed	Impervious surface root cause of water quality decline with urbanization	3.1.2	Threshold	Down
	Regional natural resource damage	Group of several indicators	Regional growth patterns can damage or limit damage to local environment	3.1.4	Relative	Down
	[Habitat fragmentation TBD]	[TBD]	Habitat fragmentation is chief contributor to biodiversity decline	3.1.5	[TBD]	[TBD]
	Greenhouse gas emissions	$MMTCO_2e$	Reflects need to mitigate climate change	4.1.3	Target	Down
	Environmental Footprint	Acres per person	Measures change in regional pro rata share of global carrying capacity	3.1.1	Relative	Down
	Petroleum consumption	Millions of gallons per year	Reflects need to reduce dependence on non-renewable fuel	4.2.2	Relative	Down
	[Air quality TBD]	[TBD]	Reflects need to go beyond conformity requirements	3.1.3	[TBD]	[TBD]
	Total energy use	Trillions of British Thermal Units	Measures energy efficiency of scenarios	4.2.1	Relative	Down
	Water use	Use/yield ratio; millions of gallons /day	Indicates whether growth occurs in water-rich or water-poor areas	4.2.2	Threshold	Optimize
P1	Total factor productivity (stratify by target	Percent change from baseline	Roughly indicates sustainability by equation with efficiency of production	3.2.2	Relative	Up
	Wage growth (stratify by target industry)	Percent change from baseline	Reflects fundamental economic development objective	3.2.2	Relative	Up
	Employment growth (stratify by target	Percent change from baseline	Reflects fundamental economic development objective	3.2.2	Relative	Up
	Aggregate fiscal capacity	Equalized assessed value + taxable	Indicates total improvement to fiscal base of local government	3.2.3	Relative	Up
	Trip length	Miles, minutes	Measures quality of life effect from transportation improvements	3.2.4	Relative	Down
	Hours of delay	Hours per year	Measures quality of life effect from transportation improvements	3.2.4	Relative	Down
	Availability of transportation modes	Percent of total trips	Measures quality of life effect from transportation improvements	3.2.4	Relative	Up
F2	Roadway in disrepair	Miles	Measures outcome of preserving manufactured capital	3.3	Relative	Down
	Bridges in disrepair	Number	Measures outcome of preserving manufactured capital	3.3	Relative	Down
	Condition of transit assets	FHWA rating index	Measures outcome of preserving manufactured capital	3.3	Relative	Up
P1	Gini for income distribution	0 to 1 scale, no units	Reflects level of equality in household income distribution	3.4	Relative	Down
	Gini for municipal tax base	0 to 1 scale, no units	Reflects level of equality in tax base among municipalities	3.4	Relative	Down
	Access to transit	Percent of total trips	Measures equity in distribution of transportation benefits	3.4	Relative	Up
	Access to jobs	Percent jobs within given commute	Measures equity in distribution of transportation benefits	3.4	Relative	Up
	Trip length	Miles, minutes	Measures equity in distribution of transportation benefits	3.4	Relative	Down

TBD = To be determined

4. Cross-Cutting Issues

A number of topics that derive from the future-orientation of sustainability thinking have never been dealt with in any detail in the regional planning efforts of NIPC and CATS. Among these are climate change, resource use and renewability, and adaptive governance. It is recommended that the Regional Comprehensive Plan include policies and projects that address these issues, as discussed in the subsections below. This list is far from comprehensive with regard to topics in regional sustainability, neglecting energy use and electric generation, solid waste and recycling, etc. and a number of other issues that fall under the sustainability rubric. Its purpose is to introduce the topic.

4.1 Climate Change

4.1.1 Introduction

A steady and steep rise in global greenhouse gases (GHG)[58] over the past century has been linked to global climate change.[59] Global GHG levels increased 25 percent over the last 150 years, largely due to industrialization. If current trends continue, world carbon dioxide emissions are expected to increase by 1.9 percent annually between 2001 and 2025.[60] The increase in concentrations of atmospheric GHG is thought to have caused worldwide average temperatures to increase by 1.37 degrees Fahrenheit over the past century with most of the change occurring over the past 50 years.[61] World wide, increasing temperature is causing economic and political instability as desertification in poor southern hemisphere nations puts stress on vulnerable populations, while melting ice caps and increasingly extreme whether have begun to affect more wealthy northern hemisphere nations.[62]

Table 5. Estimated greenhouse gas emissions for the Chicago region (excluding Kendall County).

	2000		2050 Forecast	
Sector	$MMTCO_2e$	Percent	$MMTCO_2e$	Percent
Transportation*	30.5	29%	72.8	40%
Energy	63.7	63%	90.1	50%
Agriculture	0.5	0%	0.1	0%
Waste	3.6	3%	3.9	2%
Industrial Processes	5.1	5%	13.6	8%
Total	**103.4**	**100%**	**180.5**	**100%**

Source: Center for Neighborhood Technology. Report to City of Chicago Climate Change Task Force. June 1, 2007.
* Excludes aviation

The Center for Neighborhood Technology has estimated that, if the baseline trend continues, GHG emissions from the Chicago region (Kendall not included) will increase from 103.4 million metric tons of carbon dioxide equivalents ($MMTCO_2e$) in 2000 to 180.5 $MMTCO_2e$ in 2050.[63] As a significant contributor of GHG, northeastern Illinois is in a position to take a leadership role in addressing climate change. In addition, by partnering with other regions in the United States and abroad, the Chicago region has the opportunity to influence national and international climate change initiatives.[64] The problems of climate change are, essentially, planning problems. It is recommended that the Regional Comprehensive Plan address the possibility and magnitude of climate change by including strategies that reduce GHG emissions. As indicated in Table 4, the indicator for climate change mitigation under the Regional Comprehensive Plan scenarios should be GHG emissions. Climate change mitigation techniques have the potential to offer many additional benefits to the region including reduced energy expenditures, reduced commuting times, and economic development gains. On the other hand, inaction may have serious consequences. The potential problems that may arise with increasing temperature and extreme weather events include an increase in heat related deaths or injuries in the summer, changes in ecosystem

composition, economic destabilization due to changes in the types of crops viable for agricultural production in the region, increased frequency and severity of flooding, and changes in Lake Michigan water levels.[65]

It is expected that the main influence of the Regional Comprehensive Plan on GHG emissions will be through the transportation sector. As Table 5 shows, the transportation sector (aviation excluded) produced about 29 percent of regional GHG emissions in 2000 and may produce 40 percent in 2050 if current trends continue. Thus, concentrating on core areas of influence, transportation and land use, could allow CMAP to make important reductions in GHG emissions. A minimal approach would involve accounting for GHG reductions solely from strategies meant to hold vehicle miles traveled (VMT) in check — which includes land use strategies as well — as these techniques are already expected to be part of the scenarios' suite of recommendations. As discussed in Section 4.1.3, however, this will not be enough to meet ambitious GHG reduction goals.

Climate change is typically addressed through two separate approaches: mitigation, which attempts to decelerate climate change by reducing GHG emissions, and adaptation, which seeks to cope with the effects of climate change. As the effects of climate change in northeastern Illinois remain unclear, it is not expected that the Regional Comprehensive Plan will be able to advance adaptation strategies. While there is significant uncertainty regarding future global climatic conditions, the uncertainty is even more pronounced at the regional scale.[66] Added to this is the difficulty of developing credible scenarios of social and economic impacts. It is therefore proposed that CMAP commit to playing a central role in ongoing technical assistance to local governments in the region, in collaboration with the state and with non-profit organizations, to assess the effects of climate change and to respond to them in advance of crisis. This is discussed more fully in Section 4.3, as part of *adaptive governance*.

The following sections discuss the current policy environment in which decisions regarding climate change mitigation are taking place, then delve briefly into mitigation strategies recommended for the Regional Comprehensive Plan.

4.1.2 Climate Change Policy

4.1.2.1 International

The United Nations Framework Convention on Climate Change (UNFCCC) was formed to develop collaborative efforts among nations to mitigate climate change. As a result, the Kyoto Protocol was established in 1997 as a legally binding agreement to reduce greenhouse gases. The Protocol was ratified by 175 countries, 36 of which are required to reduce greenhouse gas emissions. The overall reduction requirements are 5 percent below 1990 levels in the commitment period of 2008-2012.[67] The Kyoto agreement divides countries into three groups: Annex I Parties; Annex II Parties; and Non-Annex I Parties.[68] As a part of the Kyoto agreement, Non-Annex I countries are able to sell GHG reduction credits to Annex I countries but are not themselves required to reduce GHG emissions. The United States did not sign the Kyoto Protocol based primarily on objections related to this provision. The President has since proposed an alternative to Kyoto to take effect after 2012, which is discussed below. A number of local and state governments throughout the United States have enacted policies similar to the Kyoto Protocol. These groups include the State of California and the U.S. Mayors Climate Protection Agreement.

4.1.2.2 National

The U.S. Environmental Protection Agency (EPA) has developed several voluntary programs to encourage GHG emissions reductions. In 2002 the White House set a goal to reduce GHG emissions by 18

percent during the 10 year period between 2002 and 2012. The plan includes voluntary reporting programs, increased funding for climate research, increased funding for technology research, and funding for forest preservation in Congo, Malaysia, Peru, and Bolivia.[69] There are a number of specific endeavors including a clean energy initiative, a waste management program, and the Methane to Markets program. Each of these programs is market-based and includes funding for research and development actions and no enforcement policies.[70] In June 2007, President Bush announced a project to promote a framework plan for climate change that includes strict standards for developing countries. The plan is to take effect after the Kyoto commitments expire in 2012. Furthermore, the current energy bill, still up for debate in the U.S. House of Representatives and the Senate, contains a number of that would reduce GHG emissions by exploiting alternative energy production sources, new technologies, and conservation.[71]

Perhaps the most significant recent bellwether is the Supreme Court's April 2007 ruling that the EPA has the authority to regulate GHG emissions. The State of Massachusetts had brought suit against the EPA alleging that its failure to regulate GHG from the transportation sector had contributed to global warming and the subsequent loss of Massachusetts coastline. In a 5-4 decision, the U.S. Supreme Court held that regulating GHG from the transportation sector was within the purview of EPA given in the Clean Air Act. The Court ruled that, in the Clean Air Act, public health and welfare are broadly defined to include the destruction of the Massachusetts coastline and that the definition of an air pollutant does not preclude carbon dioxide. This ruling may lead to regulation of GHG and seems to legitimize the greenhouse gas regulation efforts of state and local governments.[72] However, experience with the issuance of transportation conformity regulations for eight-hour ozone and fine particulate matter under the Clean Air Act suggests that any rulemaking process would be a number of years in the making.

4.1.2.3 Climate Registry and Chicago Climate Exchange

The Climate Registry is a voluntary reporting program formed by the California Climate Action Registry, the Western Regional Air Partnership, the Lake Michigan Air Directors Consortium, and Eastern Climate Registry that has established standards for greenhouse gas reporting. The Climate Registry uses a baseline year of 1990 and reduction goals equivalent to those defined in the Kyoto Protocol. The Climate Registry is focused on defining a clear set of tools that measure GHG emissions uniformly across different economic and geographic areas. The Climate Registry hopes to establish its tools as the standard for any future regulatory action.[73]

The Chicago Climate Exchange (CCX), like the Climate Registry, provides a framework for reporting GHG emissions but also offers opportunities for buying and selling credits and futures. Participating groups are organized into a two-tier framework depending on the time of joining the Exchange. Phase I members include those who joined CCX between 2003 and 2006 and commit to reduce emissions by 1 percent from a baseline established by averaging annual emissions between 1998 and 2001. Phase II members include those who join the Exchange after 2006. Phase II members must reduce their emissions by 6 percent below the baseline by 2010. The baseline for Phase II members is either the average of annual emissions from 1998-2001 or the single year 2000. Phase II members commit to reduce 1 percent per year below Baseline, for a total of 4 percent by 2006.[74]

4.1.2.4 California

California has worked aggressively to reduce GHG emissions within the state and has become a center of innovation in global climate change technology. To this end, California has set a target of reducing GHG emissions within the state to 1990 levels by 2020, a 25 percent decrease from projected GHG emissions.

California is the only state that has imposed a legally enforceable limit on GHG emissions.[75] Emissions reduction will be achieved through short and long term strategies, as well as partnerships between California and other governing bodies (such as New York State, Canada and the EU) for a GHG cap and trade system. The cap and trade system will primarily affect major industries such as gas and oil refineries as well as cement manufacturing. Industry sectors that are not included in the cap-and-trade GHG system are being regulated using other mechanisms and recommendations including a more efficient transportation system, more compact land development, and cleaner, more efficient transportation operations. California is also positioning itself to benefit economically from climate change technology, providing grants and loans for research and development.[76]

4.1.2.5 Illinois and the City of Chicago

Governor Blagojevich initiated the Climate Change Advisory Group (CCAG) under an Executive Order in October 2006. [77] The Illinois General Assembly had in 1991 established a state task force, with the Illinois State Water Survey as the lead agency, to assess the degree of expected impacts on the state's economy and environment and establish a foundation for developing state policy regarding national proposals for mitigating climate change.[78] The current focus areas of the CCAG and the World Resource Institute, its research contractor, include assistance with the Climate Registry and the development of recommendations for climate change mitigation strategies for Illinois. The transportation-related policies now under consideration are GHG emissions standards for passenger vehicles, low-carbon vehicles for government fleets, high speed rail upgrades, incentives for fuel efficient vehicles, a renewable fuels or low carbon fuels standard, and finally the expansion of transit and encouragement of smart growth.[79] These are meant to achieve the goals of reducing GHG emissions to 1990 levels by 2020 and to 60 percent of 1990 levels by 2050.[80]

The City of Chicago joined 187 other cities in the U.S. Mayors Climate Protection Agreement. The agreement follows the conventions established by the Kyoto Protocol and suggests guidelines for municipal efforts to reduce GHG. Chicago began attempts to develop renewable power sources, including solar panels on many city buildings. Additionally, all new city buildings include building management systems and 22 new projects have applied for LEED certification. Beyond building technologies, Chicago has invested in alternatively fueled vehicles in the city fleet, developed a reduced idling plan for city vehicles, and established a procurement process that favors high efficiency vehicles. The Chicago Park District has developed a number of initiatives including low- and no-mow zones, Integrated Pest Management Techniques, and the use of recycled materials in playgrounds and buildings. The Department of Construction and Permits grants expedited permits to developers of green buildings and provided 20 grants for the construction of green roofs. Chicago has invested heavily in bike lanes, converted significant numbers of traffic lights to light emitting diode (LED), and initiated a landscape ordinance that has resulted in 47,000 new trees within the city. The Department of the Environment's 2006 Environmental Action Agenda details specific actions already taken by the city and goals for both 2010 and 2030.[81] Additionally, the Department of Environment and Global Philanthropy Partnership are cooperating to develop Chicago's Climate Change Task Force. The Center for Neighborhood Technology is conducting research for the Climate Change Task Force to quantify the effectiveness of specific mitigation techniques.[82]

4.1.3 Goals and Linkages

It is important for the Regional Comprehensive Plan to complement the objectives of other organizations and levels of government, as they are partners in implementation of the plan. While, again, the state of the practice is changing rapidly, the most ambitious GHG reduction targets seem to hover near 80 percent

by 2050 (Table 6). The City of Chicago's Climate Change Task Force (CCTF) has adopted this as a working target, as have the State of California and the City of Berkeley, California.[83] For the CCTF, this translates into a *preliminary* sub-target of reducing Chicago VMT in 2020 to 90 percent of VMT in 2000.[84] Were this sub-target scaled up to the region, it would require a 25 percent reduction in forecasted regional VMT in 2020 — that is, an additional VMT reduction of 25 percent beyond that expected from implementing the *2030 Regional Transportation Plan*.[85] Such an expectation would be problematic given that a recent meta-analysis of projections from 80 regional plans in the U.S. showed only a 2.3 percent average reduction in VMT below the *baseline* trend over a twenty-year period, with the best-performing plan achieving 17 percent.[86]

Table 6. Summary of greenhouse gas emissions targets for selected organizations.

		CNT/City of Chicago	Chicago Climate Exchange		State of California	State of Illinois	U.S. Mayors	Kyoto Protocol
			Phase I	Phase II				
Baseline Year		1990	1998-2001 avg	1998-2001 avg or single year 2000.	1990	1990	1990	1990
Reduction Target*	2006		4%					
	2007		4.25%	1.50%				
	2008		4.50%	3%				5% avg (varies between countries)
	2009		5%	4.50%				
	2010		6%	6%				
	2012	7%					7%	
	2016	15%						
	2020	25%			1990 levels	1990 levels		
	2025	35%						
	2030	50%						
	2040	70%						
	2050	80%			80%	60%		

* Targets are expressed as percent reductions from emissions in the baseline year.

Two conclusions can be drawn from this discussion. First, VMT reduction *alone* probably will not be enough to make significant GHG reductions for the transportation/land use sector. Recent studies indicate, however, that increased residential densities can reduce per capita GHG emissions apart from transportation-related emissions,[87] and a number of techniques available to the transportation sector are briefly discussed in the next few sections. Second, targets should be chosen that are within the range of effectiveness for a given mitigation technique. Unlike most of the other indicators for sustainability, it is recommended that specific targets be adopted for the Regional Comprehensive Plan. It appears that sufficient climate change research has been conducted to develop reduction targets, which would presumably step global targets down to the regional scale. It is recommended that the planning process establish such targets in the lead-up to the scenario analysis.

4.1.4 Climate Change Technologies

Responding to global climate change requires technological innovation that enables individuals, industries, and governmental bodies to retain the benefits of an advanced industrial economy while producing fewer GHG. Green technologies are seen by many as the next economic boom industry that will provide opportunity for a generation of entrepreneurs.[88] Climate change technologies are designed

to reduce GHG in the atmosphere. These technologies are designed to achieve this goal in three distinct ways.

1. By reducing GHG production through conservation techniques, such as more efficient cars or better insulated buildings.
2. By developing alternative energy sources or production methods that produce fewer GHGs, such as substituting solar energy production for coal energy production.
3. By capturing and sequestering GHG that are emitted into the atmosphere, as with methane capturing techniques in landfills.

These three methods for reducing GHG are often interrelated, for example technological advances in energy production can lead to more efficient technologies. This report examines technologies that stress all of these GHG mitigation techniques. Cost is a significant obstacle to the implementation of technologies that reduce climate change. This report will examine the feasibility of climate change technology both in terms of the technical possibilities of implementing a specific technology and the cost of implementing that policy. This section of the report will cover technologies that reduce GHG or mitigate climate change in the categories of passenger and freight transportation, corresponding to the precept that CMAP should focus on transportation.

4.1.4.1 Biofuels

Biofuels can be produced using renewable resources like corn, wheat, or fruit. The stalks and leaves that are left over from food production are currently considered the most feasible renewable energy source. Ethanol, which is a distillate of plant starches and sugar, is currently the most produced and used biofuel for transportation in the United States. However, "cellulosic" ethanol, which breaks down the fibrous portion of plants, has the potential to be a more energy efficient and to place less stress on food systems and crop production because they are derived from the inedible parts of plants. Traditional ethanol production requires that the grains are heated, which is done using oil and other GHG emitting energy sources. Cellulosic ethanol production on the other does not require heat. Estimates of energy production from these two methods vary widely and are the subject of scientific debates. Most sources concur that ethanol saves 20–40 percent of the GHG for the same amount of energy as petroleum based fuels.[89] Cellulosic ethanol studies show that the potential GHG reductions are between 67 percent and 89 percent.[90]

The production of ethanol from traditional distillation techniques has been accelerating quickly over the past decades from 175 million gallons (MG) in 1980 to 1,630 MG in 2000, to 4855 MG in 2006.[91] Currently only about 1 MG of ethanol is produced using the cellulosic production method at a demonstration facility. The growth of ethanol fuel production will probably continue rapidly over the next few decades. This is likely to accelerate, as Congress is preparing to pass a bill expected to increase production.[92] "Renewable fuel" refers to current methods of distilling ethanol fuels and "advanced biofuels" anticipates large-scale production of ethanol using the cellulosic technique.[93]

4.1.4.2 Fuel Cell Vehicles

Fuel cells use hydrogen and oxygen to create electricity that drives motors. Fuel cell vehicles can either be fueled with pure hydrogen gas, which is stored on board the vehicle in high pressure tanks, or they can be fueled with hydrogen rich fuels such as methane, natural gas, or even gasoline. When using fuel sources other than pure hydrogen the fuel must be converted to hydrogen using an onboard device called a "reformer".[94] Fuel cell vehicles do not emit GHG, but they are still not commercially viable – and still

face two major hurtles to becoming a GHG saving transportation technology that can be widely adoptable. [95] Hydrogen fuel cell technology is currently not viable because of the cost of producing the cells and because of the lack of hydrogen fueling station infrastructure.[96] According to some estimates the cost of producing hydrogen fuel cells must be reduced by a factor of 10 in order for the technology to be mass marketed. Fuel cells require a significant amount of the costly precious metal platinum to produce membranes that generate electricity. While there are several private firms that are attempting to achieve similar results with less expensive materials, this process has not been perfected.[97] Fueling station infrastructure is the second impediment to mass use of hydrogen fuel cells. Currently there are few hydrogen fueling stations. California and Florida have implemented hydrogen fueling infrastructure, which is mostly oriented toward fleet vehicles.[98]

4.1.4.3 Plug in Hybrids

Plug in Hybrid Electric Vehicles (PHEVs) – which are hybrid gasoline/electric cars that can be plugged in to conventional electric sources to recharge batteries – can average 100 miles per gallon or more. An Argonne researcher reached consensus with researchers from other national labs, universities, the Air Resources Board, automakers, utilities and AD Little to estimate in July 2002 that PHEVs using nighttime power reduce greenhouse gas emissions by 46 to 61 percent.[99] Plug in hybrid cars have two features which enable them to get much better gas mileage than either traditional gasoline powered cars or hybrid gasoline/electric cars. First, whereas traditional hybrid cars use a combination of the gasoline engine and the battery powered electric motor at all speeds, PHEVs use the electric battery exclusively until battery power runs out. Second, PHEVs do not rely on the gasoline engine to recharge the batteries; rather the battery is recharged by plugging the car into a traditional electric socket.

PHEVs consume less energy, even when electric power generation is taken into account. A collection of studies have shown that that while power-plant pollution would rise with wide-scale adoption of plug in hybrid technology, car emissions would fall by a much larger amount. Total energy use per car would drop by up to 45 percent, calculates the Electric Power Research Institute. EPRI[100] and the California Air Resources Board also calculate that replacing regular cars with plug-in hybrids would reduce pollution and carbon dioxide emissions up to 50 percent overall.[101]

It costs $2,000–3,000 to adapt a traditional car and approximately $5,000 to adapt a SUV into a plug in hybrid.[102] The initial cost of purchasing a PHEV, or adapting a traditional hybrid in to a plug in, can be made up in savings in fuel costs. Based on current electricity and gas prices, the cost of charging a PHEV is about one-fourth the cost of purchasing gasoline. Additionally, because plug in hybrids are expected to be plugged into the power grid during off-peak hours, current electricity generation capacity should be able to handle the additional draw without new infrastructure costs.

4.1.4.4 Freight

In 2005 freight accounted for between 19-35 percent of total greenhouse gas emissions in the transportation sector.[103] Within this, rail, air, and pipeline efficiencies have increased; however, fuel efficiency within the trucking industry has declined 12 percent between 1990 and 2005. There are a number of technique to increase the fuel efficiency of the freight system, including switching freight to rail alternatives when possible, idling reduction polices, shipping only full truckloads, giving preference to shippers who practice environmentally sound practices, using correctly-sized vehicles for trips, and converting diesel fueled equipment to electric.[104]

The EPA has partnered with numerous freight carriers, shippers, and logistics companies in the Smartway partnership, a voluntary program aimed at reducing greenhouse gases and air pollutants from the freight industry. The program has several aims including: creating partnerships; providing and developing innovative financing for program partners; establishing the National Transportation Idle-Free Corridors Program; and maximizing rail efficiency and intermodal operations. The Smartway program also provides an evaluation of each of the freight companies that participate in the program.[105]

4.2 Resource Use and Renewability

4.2.1 Fossil Fuels and Energy Use

According to the U.S. Government Accounting Office, most studies estimating the year of peak oil production place it sometime between the present and 2040, that is, within the timeframe of the Regional Comprehensive Plan.[106] If current reliance on petroleum were to continue without substantial implementation of alternative technologies — presently they supply the equivalent of only 1 percent of nationwide oil consumption — the years following the peak would see a decline in oil production, a sharp rise in the cost of petroleum, and likely severe "economic adjustment" over the long term. As with air quality, climate change, water quality, and a number of other social–environmental issues, much depends on the actions of the federal government in the upcoming years, e.g., increasing fuel economy standards and continuing to incentivize production and use of alternative fuels. However, it stands to reason that northeastern Illinois could buffer itself to some extent from the consequences of ever-higher fuel costs by early adoption of alternative technologies as well as measures that reduce automobile dependence. Strategies should focus on the transportation sector, as it is the only use sector in which the growth of nationwide petroleum consumption has not leveled off,[107] and in particular on passenger vehicles, which consume 60 percent of petroleum used in the transportation sector.[108]

Unlike climate change, which in recent years has moved solidly into the mainstream, the notion of oil production hitting a peak and declining thereafter seems to remain fringe. This may be due partly to uncertainties about unconventional oil, petroleum resources such as the tar sands in Alberta and oil shale in the Western and Midwestern U.S. states. It has been suggested that known unconventional oil resources (most located in North America) exceed world conventional supplies and that full development of the unconventional base could supply U.S. demand for perhaps a century.[109] Conservationists respond that the environmental damage associated with extracting and processing petroleum from tar sands and oil shale is unacceptable.[110] Most agree that the investment climate is risky for petroleum companies and that long lead times will be involved before substantial production is profitable. Because of weak and uncoordinated federal action either to expand oil production or to encourage alternative technologies, as well as the additional sustainability requirement of limiting the many externalities caused by the Chicago region's petroleum demand, the Regional Comprehensive Plan should consider strategies to decrease fossil fuel use in transportation. Strategies aimed at reducing VMT will partly accomplish this, but it should also consider expanding use of bio-fuels as well as freight-related strategies. If VMT reduction has the effect of reducing the need for new construction of highway facilities, it could also help contain the overall cost of major capital investments — construction costs are escalating for state departments of transportation across the U.S., mainly because of higher fuel prices[111] — and thereby stretch limited capital funds further. The primary indicator for the Regional Comprehensive Plan should be the projected petroleum consumption of the region (Table 4), where the indicator should be treated in the relative sense as a tool to compare scenarios.

Beyond strategies to decrease reliance on petroleum, the Regional Comprehensive Plan should attempt to minimize total energy use and encourage a shift to renewable energy sources. Little will be said here about energy efficiency and a shift to renewable energy, as the subject is complex and warrants a longer

treatment elsewhere. Both the City of Chicago[112] and Gov. Blagojevich[113] have released energy plans in the past few years oriented toward clean technologies and energy efficiency, and these may be helpful comparables for energy performance improvements under Comprehensive Plan scenarios. Concentrating again on land use and transportation, a growing body of research suggests that many of the same measures that would reduce GHG emissions also reduce energy consumption.[114]

4.2.2 Water Supply

In 2001, NIPC released data suggesting that eleven townships in the region could suffer drinking water shortages by 2020.[115] The data on which those estimates were based were limited and uncertain, as they relied on an incomplete understanding of the potential yields of both the shallow and deep aquifers in the region.[116] Because of the NIPC study, research by the Illinois State Water Survey (ISWS), policy work by Openlands Project, Metropolitan Planning Council, and the Campaign for Sensible Growth,[117] and finally the ongoing water supply planning efforts of several counties — Kane, McHenry, and Lake in particular — Governor Blagojevich issued Executive Order 2006-01, calling for the development of water supply plans in two priority areas in the state. One of these is an eleven-county area that includes the seven CMAP counties plus the ring of four contiguous counties. The Illinois Department of Natural Resources is the lead agency for the effort, with the Illinois State Water Survey and State Geological Survey providing research expertise and CMAP organizing the planning process in northeastern Illinois. CMAP then formed the Regional Water Supply Planning Group, a body of stakeholders representing a range of interest groups, to assist in developing the regional water supply plan.

Water supply for the region is an issue of sustainability on a number of levels. First, some water resources are being exploited at a faster rate than they can be replenished, even while others are incompletely utilized. The best available estimates suggest that withdrawals from the deep aquifer system exceed its sustained yield and continue to increase, despite the easing of pressure on the aquifer in the early 1980s when many suburban municipalities switched to Lake Michigan.[118] Indeed, northeastern Illinois has achieved some notoriety, at least among hydrogeologists, for the tremendous decline in water levels and degradation of quality in the deep aquifer as population shifted further from the lake and became more groundwater dependent.[119] Use of Lake Michigan is also constrained, only by "institutional scarcity:" Illinois' diversion of lake water is capped at 2.1 billion gallons per day under a Supreme Court ruling and subsequent consent decree.[120] Because of the Great Lakes–St. Lawrence River Basin Water Resources Compact, finalized in December 2005 and awaiting ratification by the Great Lakes states,[121] it is unlikely that the volume Illinois is allowed to divert from Lake Michigan each year will be increased. Even so, there appears to be Lake Michigan water available to be allocated for municipal supply, freed up partly through the conservation efforts of the City of Chicago and through declines in use stemming from deindustrialization in the region, among other causes.[122] The current Lake Michigan service area extends almost throughout Cook County, through most of DuPage, and eastern Lake County. A considerable part of the water supply puzzle, then, is the spatial mismatch between household growth trends and water availability.

The essential question for this section is how to relate the regional water supply plan to the Regional Comprehensive Plan. Because of the timing of the two projects, it may not be possible to incorporate into the comprehensive plan specific strategies — such as conservation measures, water reuse, etc. — expected to be developed as part of the water supply plan. However, strategies should be sought that would direct growth to areas of relative abundance of water resources from groundwater and Lake Michigan as part of Regional Comprehensive Plan scenario modeling. Although inland surface waters — the Fox and the Kankakee — are important, determining availability from them is complex and relatively

few areas make use of them. Strategies could specifically concentrate growth within the current, or even modestly expanded, Lake Michigan service area. As it turns out, maximizing infill development to rebuild disinvested neighborhoods and encourage the location of housing in areas well served by transit would also tend to promote optimal use of available water supplies. At the same time, however, the sustainability of using Lake Michigan is itself sometimes questioned. Because of the reversal of the Chicago and Calumet Rivers in the early part of the twentieth century, rivers which carry discharged wastewater originating as intake from Lake Michigan as well as direct diversion from the lake, the 2.1 billion gallons per day Illinois is permitted drain from the Great Lakes basin without replenishment. Furthermore, the vast majority of stormwater from older urbanized areas also is diverted from the Lake Michigan watershed because of extensive combined sewerage systems. It is still sometimes proposed that the Chicago and Calumet Rivers be "re-reversed" to restore their natural conditions,[123] but this is unfeasible for a number of reasons.

Table 7. Proposed indicators for water supply in Regional Comprehensive Plan scenario modeling.

Source	Threshold
Shallow groundwater	Use/yield < 0.9 by township
Deep bedrock aquifer	Use/yield < 1over region, or minimize
Lake Michigan	Use/availability ≈ 1
Inland surface water	None

For most of the metrics to be used as part of scenario modeling for the Comprehensive Plan, it is recommended that relative indicators be employed, generally because there is no set standard or target for the indicator in question or because insufficient information is available to identify thresholds. This approach should not be taken for water supply. While some new data will emerge — in 2008 — from the regional water supply planning process, the effects of scenarios can likely be modeled using thresholds set with reference to older data from the ISWS and to newer Department of Natural Resources information. For the shallow aquifer system, the ISWS has developed estimates of the areal recharge rate by township, i.e., the total amount of precipitation per unit area thought to infiltrate into shallow groundwater.[124] This recharge rate, or likely a fixed fraction of it,[125] can be treated as the potential yield of the shallow aquifer system. Using a per capita water demand multiplier and assumptions about the likelihood of using shallow rather than deep aquifer sources, the expected use of shallow groundwater could be estimated for a given land development pattern and compared to potential yield. The threshold would then be the ratio of use to yield, and the basis on which to decide whether one scenario is preferable to another would be the number of townships with use/yield > 0.9.[126] For the deep bedrock aquifer, the use to yield ratio is already thought to exceed unity. A similar procedure would be used, only the object would be to minimize the ratio of use to yield for the region. For Lake Michigan, it should be possible to estimate the available unallocated supply and to determine the fraction that would be used by households locating within the Lake Michigan service area under a given scenario. The threshold then would be for the ratio of Lake Michigan use to availability to approach but not exceed unity.

4.3 Adaptive Governance

As the National Research Council has pointed out, "there are no maps for navigating a transition toward sustainability."[127] The Council goes on to remark that although "capacity for long-term, intelligent investment in the production of relevant knowledge, know-how, and the capacity to use them both must therefore be a component of any strategy for the transition to sustainability… much of what societies need to know will only emerge in the course of applying knowledge to actions. A strategy for navigating the transition toward sustainability must therefore be a strategy not just of thinking but also of doing."[128]Taking the approach of learning while doing, with structured feedback to support course

corrections as experience warrants, is called adaptive management, at least when applied to resource and environmental husbandry. A more apt term in this region, with close to 300 municipalities and myriad special purpose units of government, would be adaptive governance, a name for ensuring that appropriate local capacity exists to respond to future threats (such as climate change) and to learn from the experiences of other localities. A good example of the proposed strategy is the International Council of Local Environmental Initiatives, which, through its Local Agenda 21 program, works with local governments to develop awareness of issues, establish targets for improvement, identify and implement projects, and measure progress toward sustainable development.[129] This is little different in its fundamentals from the many local technical assistance projects in the region carried out by CMAP, non-profit organizations, universities, and others. In fact, this section has less to do with the Regional Comprehensive Plan than with a concerted effort to identify the needs of local government with regard to overarching sustainability issues and to develop a technical assistance program, like programs for watershed planning, retail revitalization, etc., with the numerous possible partner organizations in the region. It is recommended that CMAP take a lead role in developing such a program.

5. Summary of Recommendations

The main text makes recommendations on a definition of sustainability, potential indicators to cover the concept, and specific elements to be included during the scenario analysis phase of Regional Comprehensive Plan ("Plan") development. The following is a summary list of these recommendations.

- The recommended principles of sustainability are the following, where *F* stands for *future* or very long-term conditions and *P* corresponds to *present* needs:
    - F1: Protect environment and improve natural resources for future generations.
    - P1: Improve economic performance and quality of life for individuals.
    - F2: Preserve the value of human and man-made capital for future generations.
    - P2: Ensure a fair distribution of life-quality.
- The indicators for sustainability are a mixture of three types:
    - Relative: compares the performance of two or more scenarios without specifying a particular standard of achievement. Most of the recommended indicators are relative.
    - Threshold: absolute measure that compares scenario performance against a critical level above or below which some effect occurs or does not occur.
    - Target: standard of achievement set with regard to practical considerations or stakeholder values rather than to a critical level.
- Specific recommendations are made for each of the principles, as follows:
    - F1:
        - The concept of carrying capacity postulates a critical or threshold level of resource consumption and environmental damage. While the concept is attractive, it will be too difficult to employ for the Regional Comprehensive Plan. The Plan can use a global indicator of environmental footprint instead.
        - Water quality should be addressed in the Plan. The root land use issue is growth in the amount of impervious surface, which should be an indicator. Additional modeling can be carried out to yield pollutant loading as well, however.
        - The Plan should seek to make air quality improvements beyond those required under the transportation conformity requirements of the Clean Air Act. Another Snapshot Report will explore this topic in more detail.
        - Natural resource damage should be described by a model that takes into account the effects of land development induced by infrastructure investment as well as

the direct and indirect effects of transportation projects. Damage should be assessed at the scenario level so that protective land use policies can be tested.
    - Principle F1 requires overall improvement to the natural resource base. Natural resource damage caused by development and transportation projects should be offset by restoration in at least one scenario.
    - Habitat fragmentation is the chief threat to biodiversity. The Plan should utilize a indicator of habitat fragmentation. Work is underway to identify potential indicators.
- P1:
    - Principle P1 essentially requires the Plan to address economic development, fundamentally to concentrate on increasing employment and raising income.
    - Part of economic development is enhancing the economic performance of firms in the region. Transportation infrastructure investment will enhance this to some degree by improving industry productivity. Infrastructure investments can also be made partly on the basis of the industries they would support. In particular, because certain industries or clusters are expected to be targeted (for their job growth potential, location advantage, etc.), the Plan should evaluate the positive or negative effects of potential infrastructure investments on the target industries. The indicators should be productivity, wage growth, and employment growth.
    - The Plan should also seek to employ non-capital intensive means of encouraging productivity growth, specifically to decouple such improvement from traffic growth.
    - Generally speaking, the Plan should include economic development strategies that directly assist firms or individuals or both.
    - Productivity is both an indicator of regional competitiveness and a (crude) measure of economic sustainability, in the sense of promoting efficiency. The recommended indicator is total factor productivity.
    - The Plan should seek to maximize aggregate tax capacity, the total equalized assessed value and taxable sales in the region.
    - The Plan should also include a scenario in which tax revenues from commercial and industrial development are distributed to municipalities more evenly.
    - Quality of life cannot readily be modeled except for a handful of indicators that relate to transportation modeling. These include overall hours of delay, trip length, and accessibility of jobs and transit. Principle P2 requires the distribution of these quality of life factors to improve equity.
    - An expanded set of quality of life indicators should be tracked on a long-term basis as part of Plan implementation.
- F2:
    - Principle F2 means that future generations must be given the opportunity to benefit from the existing transportation system, and so requires that current decisions contribute to the system's future usability.
    - Maintenance of a system that may not contribute to the well-being of future generations presents a dilemma for current spending. It is recommended that the Regional Comprehensive Plan develop a scenario prioritizing the maintenance of elements of the transportation system expected to be of highest benefit to future generations.
    - The long run solution to the dilemma is a commitment to efficient urban form.

        - The recommended indicators for assessing the preservation of manufactured capital are the number of miles of roadway in disrepair, number of bridges in disrepair, and the condition of transit assets.
        - The Plan should also utilize life cycle costing to assess potential major capital investments.
        - The preservation of human capital should be addressed as part of long-term tracking, as quality of life indicators would be.
    - P2:
        - The most appropriate position from which to judge the distribution of the goods of society, which together add up to quality of life, is that of the most disadvantaged stratum of society. An equitable decision will improve the prospects of the most disadvantaged. This is called *vertical equity.*
        - Previous transportation planning has stratified level of service improvements — the availability of transportation modes, access to transit, access to jobs, and commute times — by minority and income status. This is an appropriate way to judge the equity-enhancing effects of transportation improvements and should be continued.
- While decision rules cannot be set out in advance for balancing tradeoffs among the various principles and indicator results, it can be said that a sustainable scenario will have all the indicators pointed in the correct direction, as shown in Table 4.
- A wider set of indicators should be used to track progress in achieving the regional vision. This should be thought of as monitoring the outcome of plan implementation.
- Cross-Cutting Issues:
    - The Plan should develop and apply strategies to mitigate global climate change, i.e., techniques that reduce greenhouse gas (GHG) emissions.
        - A minimalist approach would simply tabulate the expected GHG emissions reductions from the variety of strategies, including those focused on land use, that reduce vehicle miles traveled (VMT).
        - In comparison with ambitious (but typical) targets developed by other organizations, the VMT-only approach comes up short. A variety of technology-based mitigation strategies (see Section 4.1.4) would also need to be employed.
        - Targets for GHG emission reductions should be prepared as part of Plan development.
        - GHG emissions should be an indicator for scenario planning.
    - The Plan should address energy use, reliance on fossil fuels, and water supply.
        - As for climate change, more can be done than tabulating the reductions in fossil fuel use entailed by reducing VMT. Alternative fuels and similar technologies should be featured in at least one scenario.
        - There is a strong relationship between reducing energy consumption and GHG emissions. The plan should seek energy efficiency gains through land use strategies, but also through policies to improve construction standards or to increase the region's commitment to green building, among other possibilities.
        - The Plan should utilize available thresholds for water availability from groundwater and from Lake Michigan to develop policies that would concentrate population growth in areas with relatively higher water availability.
    - Adaptive governance is a name for ensuring that appropriate local capacity exists to respond to future threats (such as climate change) and to learn from the experiences of other localities. CMAP should take a lead role in technical assistance of this kind.

6. Notes

[1] Raskin, Paul, T. Banuri, G. Gallopín, P. Gutman, A. Hammond, R. Kates, R. Swart. 2002. *Great Transition: The Promise and Lure of the Times Ahead*. Boston: Stockholm Environment Institute. Retrieved from: http://www.gtinitiative.org/documents/Great_Transitions.pdf

[2] National Research Council, Board on Sustainable Development. 1999. *Our Common Journey: A Transition Toward Sustainability*. Washington: National Academies Press.

[3] United Nations WCED. 1987. *Our Common Future: Report of the World Convention on Environment and Development*.

[4] The recitation of purpose in the Regional Planning Act of 2005 is "to plan for the most effective public and private investments in the northeastern Illinois region and to better integrate plans for land use and transportation" (Public Act 094-0510).

[5] Hawken, P., A. Lovins, and L. H. Lovins. 2000*. Natural Capitalism: Creating the Next Industrial Revolution.* Boston: Back Bay Books.

[6] Kutzmark, T. 2004. *Community Indicators: Integrating Science and Local Knowledge in Monitoring Programs* (Masters Thesis, University of Washington), p. 33.

[7] Daly, H. and R. Costanza. 1992. Natural Capital and Sustainable Development. *Conservation Biology* 6(1): 37-46.

[8] Ministry of Environment and Forests, Government of India. n.d. "Window to Carrying Capacity Based Regional Development Planning." Retrieved from: http://envfor.nic.in/divisions/cltech/index.htm.

[9] South Florida Regional Planning Council. n.d. "Florida Keys Carrying Capacity Study." Retrieved from: http://www.sfrpc.com/gis/fkccs.htm.

[10] See for example Cronin, W. 1992. *Nature's Metropolis: Chicago and the Great West*. New York: W. W. Norton.

[11] National Research Council, Committee to Review the Florida Keys Carrying Capacity Study. 2002. *A Review of the Florida Keys Carrying Capacity Study*. Washington: National Academies Press, pp. 1–2.

[12] Ibid., p. 50.

[13] "While many of these efforts to specify safety limits for human pressures on the biosphere have been helpful, the Board's inquiries found that the underlying concepts have proven to be contentious, ambiguous, and frustrating. Carrying capacities turn out to depend on available technologies and consumption practices. Efforts to specify actual critical loads or safety levels are undermined by the heterogeneity of the environment and populations at risk. In addition, thresholds turn out to be less often absolute than relative. Finally, a good case can be made that the viability of ecosystems depends less on critical levels that may be exceeded during particular episodes of stress than on the longer term regime of stresses that includes, but cannot be reduced to, such single-valued characteristics. We encountered all these difficulties in the present study, as we failed in our effort to develop criteria that could provide a "bright line" test for significant degradation of regional ecosystems and their life-support functions (see Chapter 4). Though we had no trouble identifying cases in which life support systems had been degraded or even destroyed, we were unable to turn the concepts of 'critical loads,' 'carrying capacities,' and their cousins into useful tools for navigating the transition toward sustainability." National Research Council 1999, op. cit., p. 290.

[14] Wackernagel, M., and Rees, W. 1996. *Our Ecological Footprint: Reducing Human Impact on the Earth*. Gabriola Island, BC: New Society.

[15] See for example McDonald, G. and M. Patterson. 2003. *Ecological Footprints of New Zealand and its Regions*. New Zealand Ministry for the Environment, Environmental Reporting Technical Paper TR130.

[16] See U.S. Environmental Protection Agency overview at http://www.epa.gov/owow/tmdl/overviewfs.html.

[17] Center for Watershed Protection. "Why Watersheds?" Retrieved from: http://www.cwp.org/whywatersheds_files/frame.htm. See also U.S. Environmental Protection Agency. May 2004. *Protecting Water Resources with Smart Growth*. EPA 231-R-04-002. Retrieved from: http://www.epa.gov/piedpage/pdf/waterresources_with_sg.pdf

[18] Litman, T. 2007. *Pavement Busters Guide: Why and How to Reduce the Amount of Land Paved for Roads and Parking Facilities*. Victoria Transport Policy Institute.

[19] Chicago Metropolitan Agency for Planning. 2006. *Transportation Conformity Analysis for the $PM_{2.5}$ and 8-Hour Ozone National Ambient Air Quality Standards.* Retrieved from: http://www.catsmpo.com/prog/conformity/pm25_conformity_analysis.pdf

[20] Northeastern Illinois Planning Commission. n.d. *Natural Resource and Socio-Economic Impacts of 2030 Regional Transportation Proposals: Evaluation of Projects and Alternatives.*

[21] LEAM Laboratory. 2005. Retrieved from: http://www.rehearsal.uiuc.edu/projects/leam/legacy/McHenry/html/workshops_nov_maps_2.htm

[22] Chicago Region Biodiversity Council. 1999. *Biodiversity Recovery Plan*, p. 6.

[23] Wilcove, D., D. Rothstein, J. Dubow, A. Phillips, E. Losos. *Bioscience* 48: 607 (1998).

[24] Wolman, H. and D. Spitzley. 1996. The Politics of Local Economic Development. *Economic Development Quarterly* 10(2).

[25] Organization for Economic Cooperation and Development. 2003. *Analysis of the Links Between Transport and Economic Growth.* Retrieved from: http://www.oecd.org/dataoecd/29/37/31661238.pdf

[26] Federal Highway Administration. 2002. *The Freight Story: A National Perspective on Enhancing Freight Transportation.* Retrieved from: http://ops.fhwa.dot.gov/freight/freight_analysis/freight_story/change.htm

[27] Chicago Metropolitan Agency for Planning. 2007. *Regional Snapshot*, figure 24.

[28] Chicago Area Transportation Study. 2003. *2030 Regional Transportation Plan for Northeastern Illinois*, p. 5.

[29] Federal Highway Administration. 1996. *Productivity and the Highway Network: A Look at the Economic Benefits to Industry from Investment in the Highway Network*. FHWA-PL-96-016. Retrieved from: http://www.fhwa.dot.gov/policy/otps/060320b/index.htm

[30] A number of studies are reviewed in Bhatta, S. and M. Drennan. 2003. The Economic Benefits of Public Investment in Transportation. *Journal of Planning Education and Research* 22(3): 288-296. An FHWA review shows a generally positive relationship between various types of infrastructure investment and sector or national output. See http://www.fhwa.dot.gov/policy/otps/060320a/appc.htm.

[31] See Standing Advisory Committee for Trunk Road Assessment (SACTRA). 1999. *Transport and the Economy*. Report to the United Kingdom Secretary of State for Transport, p. 35. Retrieved from: http://www.dft.gov.uk/pgr/economics/sactra/transportandtheeconomyfullre3148. One of the most well-known proponents of the value of competitive strategy, Michael Porter of Harvard, also largely equates competitiveness with productivity. See his talk *Competitiveness and the Role of Regions*, retrieved from http://www.isc.hbs.edu/pdf/Houston_11-22-2002.pdf.

[32] HLB Decision Economics Inc. 1999. *Public Policy Impacts on Freight Productivity: Final Report with Annotated Bibliography.* Report prepared for Federal Highway Administration. Retrieved from: http://ops.fhwa.dot.gov/freight/freight_analysis/econ_methods/pub_pol_impts/pub_pol_7.htm

[33] Federal Highway Administration. 1998. *A Summary of "Contributions of Highway Capital to Output and Productivity Growth in the U.S. Economy and Industries."* Retrieved from: http://www.fhwa.dot.gov/policy/nadiri2.htm. The range in cost savings reflects two separate estimates by FHWA-sponsored researchers, the latter thought to employ improved econometric techniques.

[34] Ibid.

[35] Ibid.

[36] Daly and Costanza, op. cit., p. 44.

[37] Pieper, U. 1999. *Deindustrialization and the Social and Economic Sustainability Nexus in Developing Countries: Cross-Country Evidence on Productivity and Employment*. Working paper of Center for Economic Policy Analysis, New School for Social Research. Retrieved from: http://www.newschool.edu/cepa/papers/archive/cepa0110.pdf

[38] See for example chapters 9 and 10 in Harrison, B. 1994. *Lean and Mean: the Changing Landscape of Corporate Power in the Age of Flexibility*. New York: Basic.

[39] Redefining Progress. 2006. *Genuine Progress Indicator*. Retrieved from: http://www.rprogress.org/publications/2007/GPI%202006.pdf

[40] SACTRA, op. cit.

[41] Goetz, E. and T. Kayser. 1993. Competition and Cooperation in Economic Development: A Study of the Twin Cities Metropolitan Area. *Economic Development Quarterly* 7(1).

[42] Reviewed in Wolman and Spitzley, op. cit. There are a number of other views of the matter, also reviewed in Wolman and Spitzley, including the "growth machine" theory according to which self-interested elites promote local economic development — generally real estate development — to benefit from the rise in land values and rents that follow.

[43] Ibid.

[44] Goetz and Kayser, op. cit.

[45] Ibid.

[46] Compare the use of narrative scenarios in Swart, R., P. Raskin, and J. Robinson. 2004. The Problem of the Future: Sustainability Science and Scenario Analysis. *Global Environmental Change* 14: 137–146.

[47] Gudmundsson H. and M. Hojer. 1996. Sustainable Development Principles and their Implications for Transport. *Ecological Economics* 19(3): 269–282, p. 278.

[48] Chicago Area Transportation Study. October 15, 1997. *Report to the Regional Transportation Committee on Projected Transportation System Revenues and Expenses*.

[49] Lee, R., P. Wack, E. Jud. 2003. *Toward Sustainable Transportation Indicators for California.* Report 02-05. San Jose, CA: Mineta Transportation Institute.

[50] For an overview, see Federal Highway Administration. 2002. *Life-Cycle Cost Analysis Primer.* Office of Asset Management.

[51] Ibid.

[52] Rawls, J. 1971. *A Theory of Justice*. Cambridge, MA: Belknap; Hall, R. 2006. *Understanding and Applying the Concept of Sustainable Development to Transportation Planning and Decision-Making in the U.S.* (Doctoral dissertation, Massachusetts Institute of Technology).

[53] Chicago Area Transportation Study. 2003. *2030 Regional Transportation Plan for Northeastern Illinois*, pp. 61 – 78.

[54] Kutzmark, op. cit. An early review of sustainability indicators can be found in McLaren, V. 1996. Urban Sustainability Reporting. *Journal of the American Planning Association* 62(2): 184-203. Sustainable Seattle is probably the best known local sustainability indicators project: see Sustainable Seattle's 1998 publication *Indicators of Sustainable Community* (http://www.sustainableseattle.org/pubs/1998IndicatorsRpt.pdf)

[55] Retrieved from: http://www.willcountyced.com/golife/default1.htm

[56] The Boston Foundation. 2007. *A Time Like No Other: Charting the Course of the Next Revolution*. Retrieved from: http://www.bostonindicators.org/IndicatorsProject/

[57] Chicago Metropolitan Agency for Planning. 2006. *Strategic Report on Visioning, Governance, and Funding*.

[58] The Global Warming Potential (GWP) measures the potential of individual gases to trap heat relative to carbon dioxide. This scale normalizes greenhouse gases by using CO_2 as the base measurement. The term CO_2e (carbon dioxide equivalent) is used to describe all emissions that trap heat and thus are greenhouse gases. With the GWP of carbon dioxide as 1, methane has a GWP of 21 (or a GWP 21-fold greater than that of CO_2), and nitrous oxide has a GWP of 310. These values are from the Intergovernmental Panel on Climate Change (1996). The standard measure for GHG emissions is millions of metric tons of carbon dioxide equivalent, or $MMTCO_2e$.

[59] Energy Information Agency, Department of Energy, "Greenhouse Gases, Climate Change and Energy", 2004.

[60] Ibid.

[61] http://ec.europa.eu/environment/climat/home_en.htm

[62] Intergovernmental Panel On Climate Change, "Climate Change 2007: The Physical Science Basis, Summary for Policymakers"

[63] The Center for Neighborhood Technology, "Chicago Greenhouse Gas Mitigation Research: Report to City of Chicago Climate Change Task Force", June 1 2007

[64] States and cities within the United States have formed coalitions with government bodies, such as Canada and the European Union.

[65] United States Environmental Protection Agency. "Climate Change and Illinois", 1997. Also Union of Concerned Scientists. 2005. "Climate Change in Illinois." Retrieved from: http://www.ucsusa.org/greatlakes/glregionill.html

[66] D. Winstanley and S. Changnon. 2004. *Insights to Key Questions About Climate Change*. Illinois State Water Survey, especially pp. 28 – 33.

[67] United Nations Framework Convention on Climate Control: Main Page. Retrieved from: http://unfccc.int/kyoto_protocol/items/2830.php

[68] Annex I Parties include the industrialized countries that were members of the OECD (Organization for Economic Cooperation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States. Annex II Parties consist of the OECD members of Annex I, but not the EIT Parties. They are required to provide financial resources to enable developing countries to undertake emissions reduction activities under the Convention and to help them adapt to adverse effects of climate change. In addition, they have to "take all practicable steps" to promote the development and transfer of environmentally friendly technologies to EIT Parties and developing countries. Funding provided by Annex II Parties is channeled mostly through the Convention's financial mechanism. Non-Annex I Parties are mostly developing countries. Certain groups of developing countries are recognized by the Convention as being especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. Others (such as countries that rely heavily on income from fossil fuel production and commerce) feel more vulnerable to the potential economic impacts of climate change response measures. The Convention emphasizes activities that promise to answer the special needs and concerns of these vulnerable countries, such as investment, insurance and technology transfer. The 48 Parties, classified as least developed countries (LDCs) by the United Nations, are given special consideration under the Convention on account of their

limited capacity to respond to climate change and adapt to its adverse effects. Parties are urged to take full account of the special situation of LDCs when considering funding and technology-transfer activities.

[69] The White House. Council on Environmental Quality. Retrieved from:http://www.whitehouse.gov/ceq/global-change.html#2

[70] United States Environmental Protection Agency. "Transportation and Air Quality." Retrieved from: http://www.epa.gov/otaq/voluntary.htm

[71] The House version of the bill allots funding for the development of alternative fuels and for increased efficiency of appliances and buildings. It would encourage research into methods for capturing carbon dioxide emissions. Additionally, the bill proposes repealing about $16 billion in tax breaks for the oil industry and using some of that funding for research grants and renewable fuel projects. The bill would also mandate that 15 percent of electricity be generated using renewable resources or zero GHG technologies — such as wind, solar, and geothermal — by 2020. However, the House version of H.R. 6 does not mandate increased fuel efficiency in automobiles, which is arguably a central component of drastically reducing GHG.[71] The Senate version of H.R. 6 does include legislation that would require auto manufacturers to increase corporate average fleet efficiency by 25 percent to 35 percent. The legislation would also require use of ethanol and other renewable fuels to grow by at least 36 percent by 2022 (see chart in ethanol section of this report for details). The Senate version also includes a clause that would make subsidized loans available for the construction of new nuclear facilities. Regardless of which of the two versions of the bill that the House and Senate approve, President Bush has threatened to veto them if they do not provide measures to increase domestic oil drilling.

[72] Pew Climate Center. Supreme Court Ruling EPA v. MA. Retrieved from: http://www.pewclimate.org/epavsma.cfm

[73] The Climate Registry: Homepage. Retrieved from: http://www.theclimateregistry.org/

[74] Chicago Climate Exchange. Emissions Reduction Targets. Retrieved from: http://www.chicagoclimatex.com/content.jsf?id=72

[75] http://www.guardian.co.uk/environment/2006/aug/31/usnews.climatechange

[76] Fact Sheet: California's Program To Reduce The Impacts Of Global Warming, Climate Action Program At Caltrans, Climate Action Team Proposed Early Actions To Mitigate Climate Change In California

[77] Illinois EPA. Climate Change Advisory Group Menu: Homepage. Retrieved from: http://www.epa.state.il.us/air/climatechange/index.html

[78] Winstanley and Changnon, op. cit.

[79] Transportation Subgroup Proposed Policies. Retrieved from: http://www.epa.state.il.us/air/climatechange/documents/subgroups/transportation/transportation-proposed-policies.pdf

[80] Illinois EPA press release. February 14, 2007. Retrieved from: http://www.illinois.gov/PressReleases/ShowPressRelease.cfm?SubjectID=29&RecNum=5718

[81] City of Chicago Department of the Environment. Retrieved from: http://egov.cityofchicago.org/city/webportal/portalEntityHomeAction.do?entityName=Environment&entityNameEnumValue=13

[82] Center for Neighborhood Technology. Archive for the Climate Category. Retrieved from: http://weblog.cnt.org/category/climate/

[83] Millard-Ball, A. August/September 2007. Pollution Solutions. *Planning* 73(8): 10–17.

[84] The Center for Neighborhood Technology, "Chicago Greenhouse Gas Mitigation Research: Report to City of Chicago Climate Change Task Force", June 1, 2007, p. 28.

[85] Calculated from VMT forecasts in 2006 CMAP *Transportation Conformity Analysis for the $PM_{2.5}$ and 8-Hour Ozone National Ambient Air Quality Standards,* p. 23. Retrieved from: http://www.catsmpo.com/prog/conformity/pm25_conformity_analysis.pdf

[86] Bartholomew, K. 2005. *Integrating Land Use Issues into Transportation Planning: Scenario Planning*. Retrieved from: http://faculty.arch.utah.edu/bartholomew/SP_SummaryRpt_Web.pdf

[87] Norman, J., H. MacLean, and C. Kennedy. 2006. Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and Greenhouse Gas Emissions. *Journal of Urban Planning and Development* 132(1): 10–21.

[88] See especially Thomas Friedman of the New York Times.

[89] http://rael.berkeley.edu/EBAMM/summary.html, Shapouri, Hosein, "The Net Energy Balance of Corn Ethanol, A Rebuttal to Graboski, Michael "Ethanol Fuels: Energy, Economics and Environmental Impacts by D. Pimentel" http://www.eere.energy.gov/afdc/altfuel/ethanol.html

[90] http://www.eere.energy.gov/afdc/altfuel/ethanol., Wang, Michael, "Ethanol, the Complete Lifecycle Picture, USDOE.

[91] http://www.ethanolrfa.org/industry/statistics/#A

[92] The bill presently being debated would require 36 billion gallons of biofuel production by 2022. Retrieved from: http://www.govtrack.us/congress/bill.xpd?tab=summary&bill=h110-

[93] Renewable Energy Initiative at UIUC http://www.renewable-energy.uiuc.edu/about/motivation.php

[94] http://www1.eere.energy.gov/hydrogenandfuelcells/tech_validation/

[95] http://www.wired.com/cars/energy/news/2004/12/66111?currentPage=2, http://news.bbc.co.uk/1/hi/sci/tech/2840191.stm,
http://web.mit.edu/afs/athena.mit.edu/org/m/mecheng/fcp/about percent20f percent20cells.html

[96] http://www.wired.com/cars/energy/news/2004/12/66111?currentPage=2, http://news.bbc.co.uk/1/hi/sci/tech/2840191.stm,
http://web.mit.edu/afs/athena.mit.edu/org/m/mecheng/fcp/about percent20f percent20cells.html

[97] http://www.wired.com/cars/energy/news/2004/12/66111?currentPage=2

[98] http://www.hydrogenhighway.ca.gov/stations_cars/stations_cars.htm
http://www.progress-energy.com/aboutus/news/article.asp?id=11263

[99] http://www.calcars.org/vehicles.html

[100] Comparing the Benefits and Impacts of Hybrid Electric Vehicle Options

[101] http://www.calcars.org/vehicles.html

[102] http://www.calcars.org/vehicles.html

[103] United States Environmental Protection Agency. May 16, 2007. "Greenhouse Gas Emissions from Freight Trucks." Retrieved from: http://www.epa.gov/ttn/chief/conference/ei16/session5/davies_pres.pdf. The range in percentage is the result of data that includes rail and air freight in a category with air conditioning emissions.

[104] EPA. Overview of Shipper Strategies. Retrieved from: http://www.epa.gov/smartway/documents/shipper_strategies.pdf

[105] EPA. Smartway Transport Partnership. Retrieved from: http://www.epa.gov/smartway/

[106] U.S. Government Accounting Office. February 2007. *Uncertainty about Future Oil Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production*. GAO-07-283. Retrieved from: http://www.gao.gov/new.items/d07283.pdf

[107] Ibid.

[108] Natural Resources Defense Council. June 2007. *Driving It Home: Choosing the Right Path for Fueling North America's Transportation Future*. Retrieved from: http://www.nrdc.org/energy/drivingithome/drivingithome.pdf

[109] AOC Petroleum Support Services. 2004. *Strategic Significance of America's Oil Shale Resource. Volume I: Assessment of Strategic Issues.* Report prepared for U.S. Department of Energy, Office of Naval Petroleum and Oil Shale Reserves. Retrieved from: http://www.fossil.energy.gov/programs/reserves/npr/publications/npr_strategic_significancev1.pdf

[110] Natural Resources Defense Council, op. cit.

[111] Federal Highway Administration. 2007. "Highway Construction Cost Increases and Competition Issues." Retrieved from: http://www.fhwa.dot.gov/programadmin/contracts/price.cfm

[112] Chicago Department of Environment. 2001. *Chicago Energy Plan.* Retrieved from: http://egov.cityofchicago.org/webportal/COCWebPortal/COC_EDITORIAL/2001EnergyPlan.pdf.

[113] Presentation by Steve Frankel, Office of Governor Rod R. Blagojevich. September 26, 2005. *Illinois Sustainable Energy Plan*. Retrieved from: http://www.aceee.org/conf/05ee/05eer_sfrenkel.pdf.

[114] Norman, J., H. MacLean, and C. Kennedy, op. cit.

[115] Northeastern Illinois Planning Commission. 2001. *Strategic Plan for Water Resources Management*.

[116] The deep aquifer system is composed of several layers of water-bearing rock overlain by a relatively impervious strip of shale that prevents infiltration of water from the surface. The recharge area mainly occurs west of the metropolitan region. The shallow aquifer system, by contrast, lacks this confining layer of shale. The work of the Illinois State Water Survey as part of the regional water supply plan for northeastern Illinois is expected to shed more light on availability, especially in the focus area of the Fox River basin.

[117] For a summary of the issues, see Campaign for Sensible Growth, Metropolitan Planning Council, and Openlands Project. December 2005. *Troubled Waters*. Retrieved from: http://www.openlands.org/reports/Troubled%20Waters%20PDF.pdf

[118] Burch, S. 2002. *A Comparison of Potentiometric Surfaces for the Cambrian-Ordovician Aquifers of Northeastern Illinois, 1995 and 2000*. ISWS Data/Case Study 2002-02. Retrieved from: http://www.sws.uiuc.edu/pubdoc/DCS/ISWSDCS2002-02.pdf

[119] See for example U. S Geological Survey. 1999. *Sustainability of Ground-Water Resources*. Circular 1186. Denver, CO: U.S. Government Printing Office.

[120] 388 U.S. 426 (1967), amended by 449 U.S. 48 (1980). More details can be found in Jaffe, M. 2001. *Water Supply Management Options for Northeastern Illinois*. Retrieved from: http://www.uic.edu/cuppa/upp/people/faculty/jaffe/index.html

[121] The State of Illinois ratified the Compact in August 2007.

[122] Low lake levels also contribute by decreasing the amount of leakage through locks, and a number of dry years have reduced the amount of stormwater runoff to be accounted for in the diversion. In a process parallel to the regional water supply plan, the Illinois Department of Natural Resources is now conducting its decennial review of Lake Michigan water allocations and will be able to determine the availability of additional supplies for municipalities in the region.

[123] For example, Miner, Michael. “They Need It. We Waste It.” *Chicago Reader*, January 13, 2006.

[124] Wehrmann, A., S. Sinclair, and T. Bryant. 2003. *An Analysis of Groundwater Use to Aquifer Potential Yield in Illinois*. Illinois State Water Survey Contract Report 2004-11.

[125] A simplification meant to account for the discharge of shallow aquifers to surface water bodies, i.e., to avoid the presumption that all shallow groundwater should be available for withdrawal and therefore that ecosystem water needs are unimportant.

[126] This is considered to be a breakpoint for stress on the aquifer system in Wehrmann et al., op. cit.

[127] National Research Council 1999, op. cit., p. 276. Retrieved from: http://www.nap.edu/openbook.php?record_id=9690&page=276

[128] Ibid., p. 277.

[129] ICLEI. “Local Governments for Sustainability.” Retrieved from: http://www.iclei.org/index.php?id=global-about-iclei