APPENDIX 3: PAST AND FUTURE TRENDS OF KEY DRIVING FORCES

The four scenarios described in Chapter 2 weave together various assumptions about the trajectories of and relationships between key driving forces. This appendix steps backwards through the initial scenario logics and the four themes of the storylines to characterize the assumptions behind the scenario development. Each of the ten driving forces is described through: a general overview and definition, historical trends of various measures in the basin and potential future trajectories. Each driver is further described in terms of specific trajectories under each scenario alongside the basis for that decision. This appendix includes the following ten driving forces (listed with page #s):

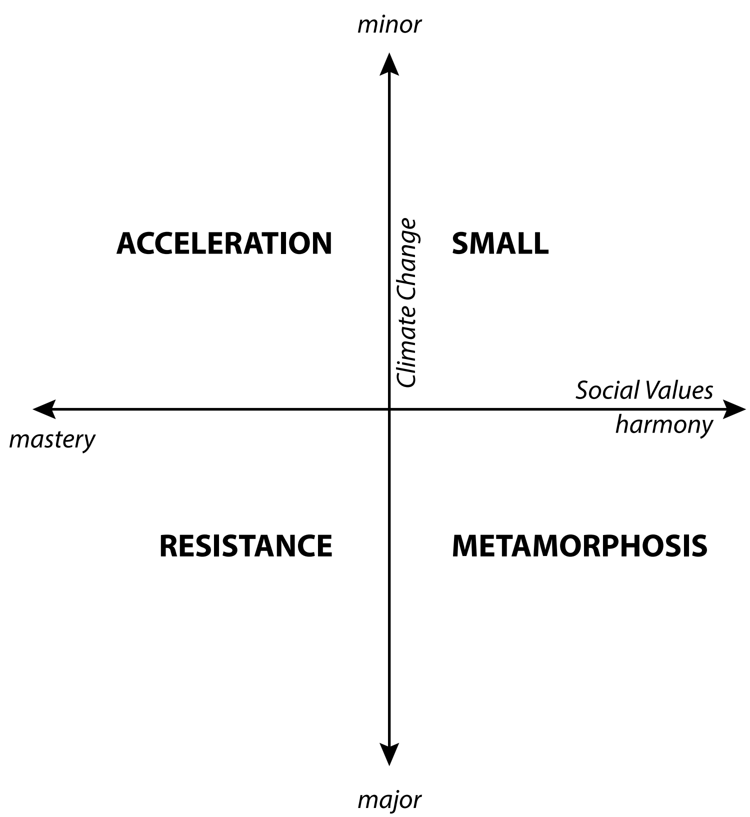


Figure A3.1 The Four Scenarios

Climate Change

Climate change refers to long-term shifts in the statistics of weather. Climate change incorporates both natural variability and human-induced change [1]. Historic records indicate the warming of the earth's average temperature by 1.1 °F since the early 20th century [2]. Furthermore, approximately two thirds of that warming has occurred since 1980 [3]. Global predictive models used by the IPCC[1] point to greater warming in the next century, as well as precipitation variability and sea level rise [4]. Implications of climate change, on both a global and regional scale are far reaching; from drinking water availability to stream water quality, from public health epidemics to species migrations and pests [4]. While some systems may benefit from climate changes, overall greater variability and exceedance of critical thresholds is predicted to destabilize current systems faster than we can adapt [5].

The Puget Sound region has and will continue to incur climatic changes differently than global averages given its unique topographic, vegetation and cycling features [6]. Past observations reveal regional changes; temperatures are rising faster than global average [2], estimates of snow water equivalent (SWE) in the Cascades reflect a substantial (~15–35%) decline from midcentury[7], and Puget Sound waters are warming as hydrological flows are shifting[2]. Downscaled models have applied global emission scenarios to the Puget Sound to forecast change at a finer resolution for the Region[8]. Emission scenarios refer to estimates of changes in future emission levels of greenhouse gases which depend upon uncertain economic sociological, technological and natural developments [9]. Two scenarios, the 'low' B1 and the 'medium' A1B have been used consistently by the region's leading climate research agency, the Climate Impacts Group, to describe the variability in future projections [10].

Multiple variables characterize climate trajectories in terms of both the forces and the implications of change. Climate forces can be described in terms of magnitude (e.g. warming and precipitation), pace, variability (e.g. seasonal), and the frequency and magnitude of extreme events. Climate change can also be described in terms of its implications on ecological systems (e.g. snowpack, streamflow, water and energy shortages, soil water availability, human health, forest structure, salmon, and nearshore habitat). The Snohomish Basin Scenarios focus on magnitude and extreme events, representing top level changes that are well understood and with significant cascading implications on economic, social and ecological systems, but that are equally uncertain.

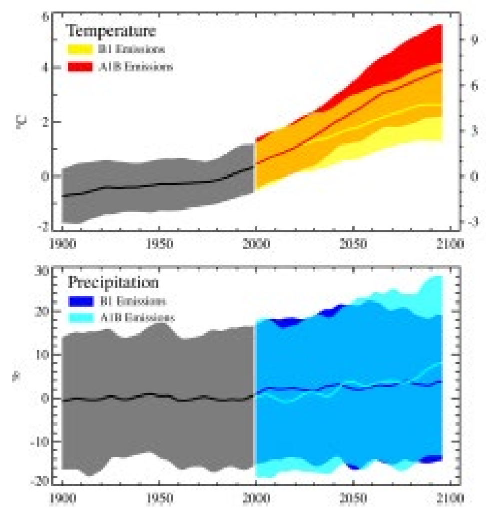


Figure A3.2 Temperature and Precipitation annual mean change [2]

Magnitude refers to the extent of change in temperature and precipitation in terms of degrees and inches and timing of rain respectively. By the 2060's the Puget Sound is projected to increase by 1-3degC annual mean (Figure A3.2). While annual precipitation is not projected to shift significantly, seasonal precipitation variability is predicted to increase, characterized by wetter winters and drier summers (Figure A3.3). Extreme events refer to weather events such as heat waves, floods, droughts, or storms that can lead to severe

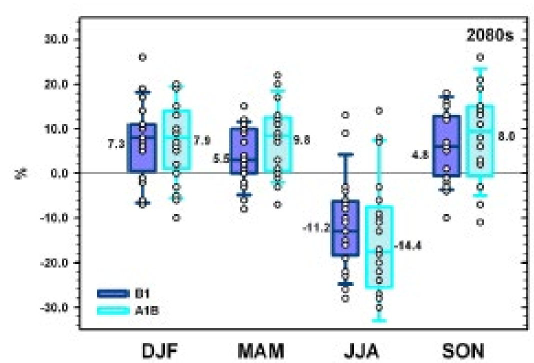


Figure A3.3 Seasonal Precipitation Variability

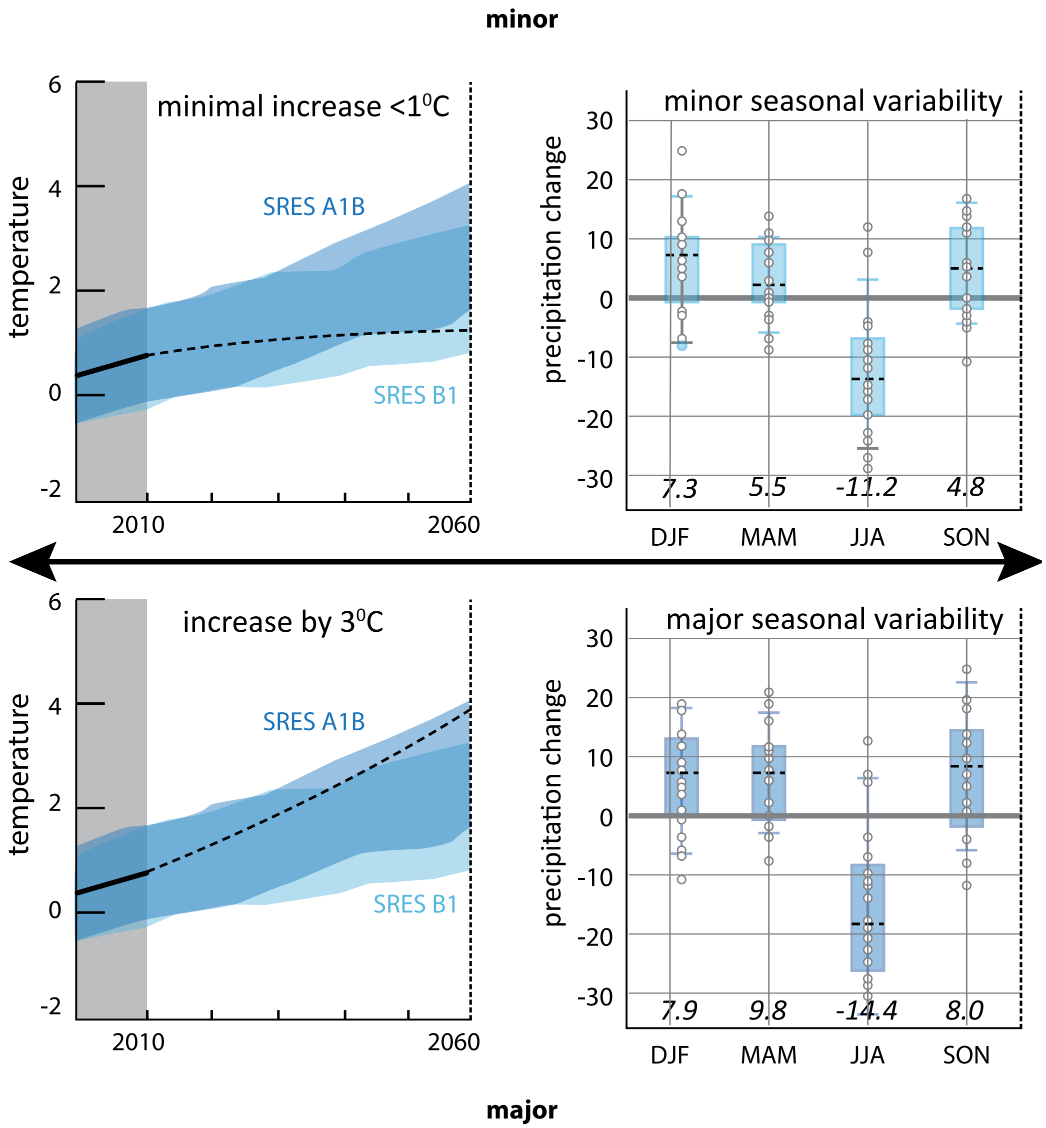


Figure A3.3 Temperature and Precipatation.

The top two diagrams represent projected trends under a 'minor' trajectory while the bottom two diagrams represent trends under a 'major' trajectory. Left side represents projected increase in mean temperature in under the downscaled A1B and B1 emissions scenarios. The right hand side represents seasonal variability in precipitation, downscaled for the Puget Sound. [17, revised] societal and economic impacts. Events are characterized as extreme if they exceeds (+/-1.5) standard deviations from the long-term means on a particular day [11]. Extreme events are tied more closely to changes in the variability than in the mean of climate change [12]. Pacific Northwest models show an agreement for moderate increases in winter precipitation increasing the frequency of extreme events [13].

Snowpack and Streamflow

Snowpack refers to layers of snow that accumulate in high altitudes [14]. In the Snohomish Basin, snowpack is an important water reservoir that feeds streams and rivers as it melts in the early spring [15,16]. Snowpack is particularly sensitive to climate change in mid-elevation 'transition' watersheds where temperature changes impact the balance of precipitation falling as rain and snow [17]. Climate change influences both the melt timing and accumulation of snowpack. Earlier snowmelt alters seasonal stream flows leading to larger and faster winter flows and lower base flows and drought in the summer [17] (Figure A3.4 and A3.5)

Streamflow changes associated with a transition watershed will challenge the basin's salmon populations, flood risks, drinking water, hydropower, recreation and vegetation. Exaggerated streamflows will impact salmon in both winter and summer, with scouring during higher flows and temperature exceedance and migration barriers during low flows [7]. Runoff timing will also put lowland watersheds at higher risk for flooding [18]. Reservoirs, including both the Tolt and Spada, currently depend on snowmelt to refill drinking water reservoirs in the spring [17]. Earlier snowmelt will put pressure on summer water resource availability, increasing the tension between withdrawal demands and in stream flow regulations [17]. Summer low-flows will influence hydropower-generation, from 13-16% by the 2040's [17]. Reduced snowpack will influence a decline in the ski industry, transitioning to summer markets [16]. Lastly, changes in snow elevations will influence the tree line with implications on white pine and other higher elevation species[17].

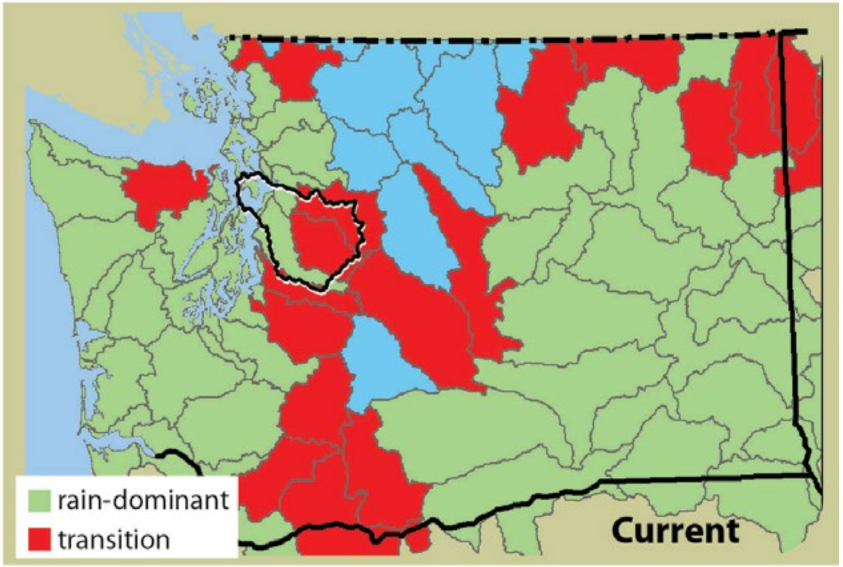
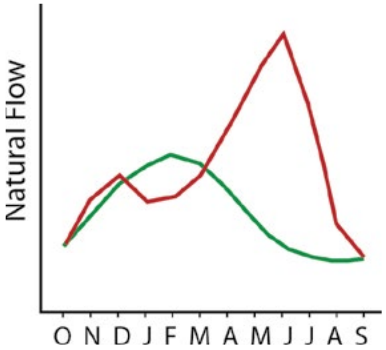


Figure A3.4 Watershed Characterization [17]

Past and Future: While both temperature and precipitation changes influence snowmelt, temperature trends are a better predictor of snowmelt than precipitation, which adds noise to the series [17]. Hydrologic models have been tested for both the A1 and B2 global scenarios for the 2040's and 2080's, utilizing the Sultan and Tolt Watersheds as case studies [17]. Under scenario A1B, the Sultan loses 88-98% of its snowpack in the 2060's with the Tolt losing slightly less, between 79-95%. Under scenario B1, Sultan loses 81-94% and the Tolt loses 70-87% [17].



Figurer A3.5 Characteristic hydrograph of transient watershed [17]

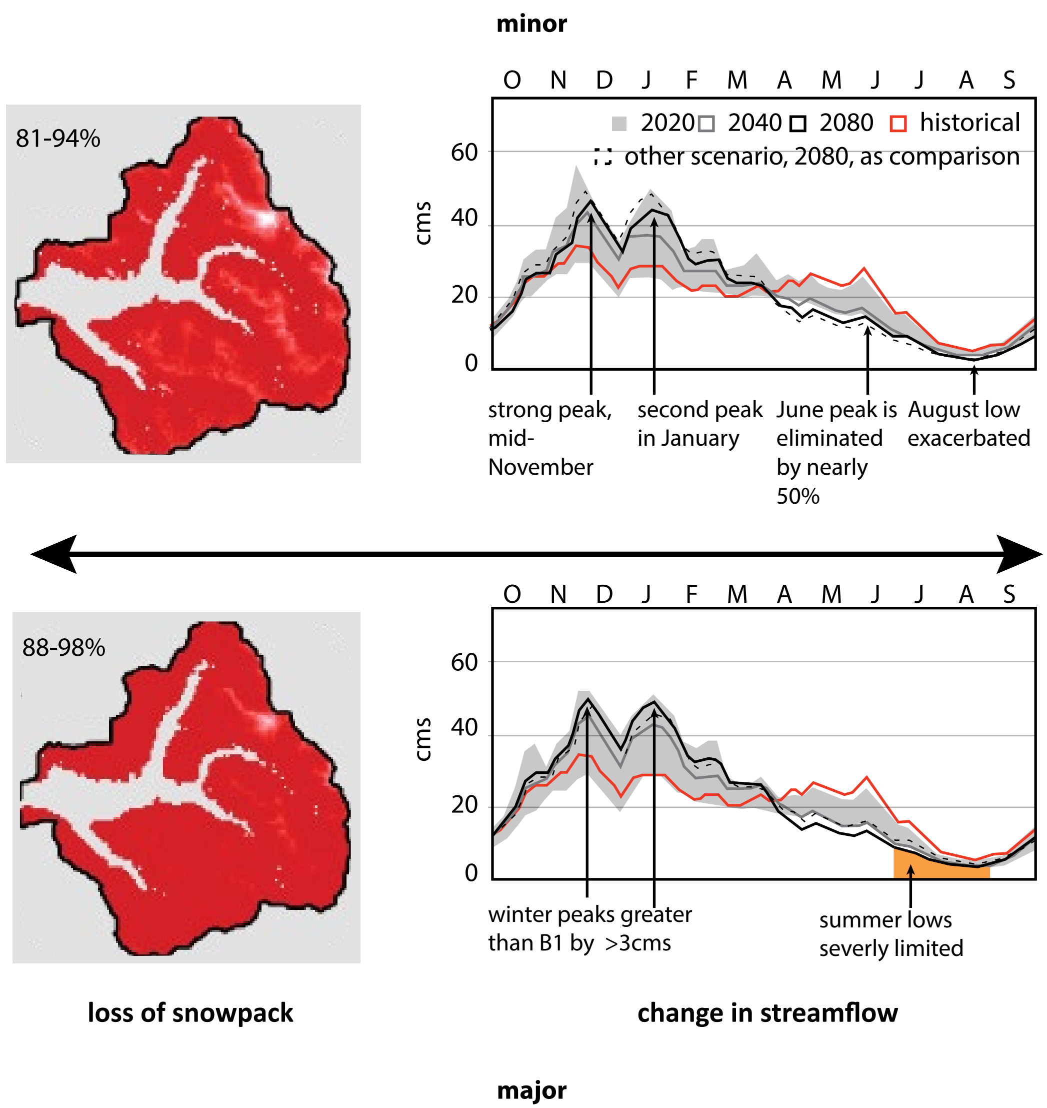


Figure A3.6 Snowmelt and Streamflow.

The top two diagrams represent projected trends under a ‘minor’ trajectory while the bottom two diagrams represent trends under a ‘major’ trajectory. Left side represents extent of snowpack loss by April 1st by 2060 in the Sultan Watershed. The Sultan watershed represents the western half of the Snohomish Basin. The right hand diagrams represent projected shifts in streamflow of the Sultan River over the next 80 years [17,revised].

Social Values

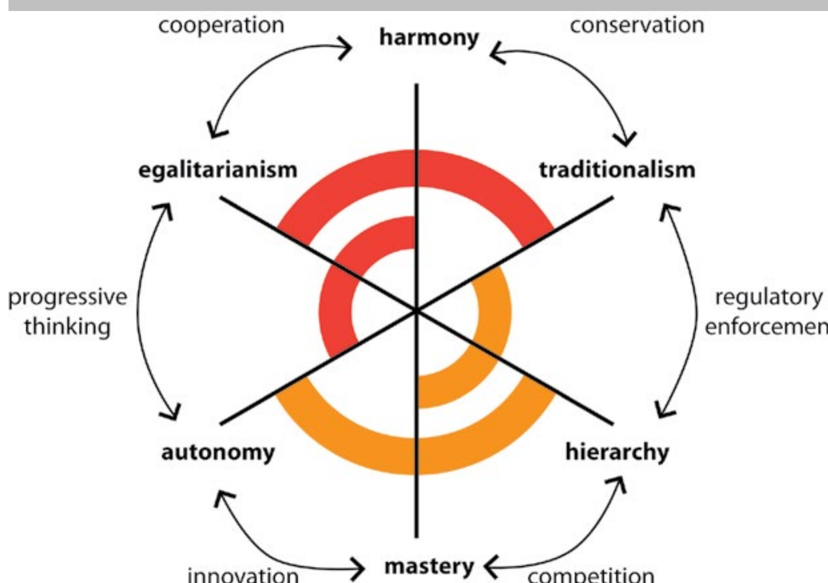
Values are beliefs about desirable behaviors that transcend specific situations, guide evaluation of behavior, and are ordered by relative importance [20]. Cultural values reflect underlying society emphases that reflect a taken-for-granted normative system (how things should be)[21]. Cultural orientations differentiate fundamental ways of defining reality, or worldviews. Societies confront basic problems in regulating human activity. Societal responses to these issues emphasize certain values and sacrifice others [22]. These emphasized values are expressed in daily practices, ways of thinking, and the ways institutions function. For example, if a culture values ambition and success, it may support competitive legal, market and education systems [23]. Value emphases also set implicit standards, action priorities, and policies in everyday settings.

There are several theories that define the dimensions of cultural values [24-30]. Each theory is one way to see the world, each somewhat subjective and limited. Schwartz has defined and defended three bipolar cultural value dimensions from societal responses to 3 basic problems: 1) what is the relationship of the individual to the group; 2) how do we guarantee socially responsible behavior; and 3) what is the relationship of humankind to nature and society? [22] The Snohomish Basin Scenarios focus on mastery and harmony responding to the third question (above). These two value endpoints reflect important and uncertain plausible trajectories of society in the Snohomish Basin over the next fifty years[2].

Past and Future: According to various social scientists, the Western World, especially the United States, is characteristic of a 'mastery' worldview while eastern cultures are predominantly 'harmonious' [31-34]. There are published correlations between mastery and capitalistic society, higher incomes and globalization [22,35], however there is no published literature describing cultural shifts over time between mastery and harmony. Literature describing, not to mention forecasting, the drivers influencing cultural values are sparse and contextually biased. Perhaps economic stability or technological innovations will lead towards greater mastery [36]? Perhaps greater public knowledge about socio-ecological resilience theory will result in harmony? Perhaps ecological pressures will result in mastery? Perhaps not. It is precisely the uncertainty of future cultural values in relationship to other drivers that makes it an effective critical uncertainty for the scenario logics.

Figure A3.7 Direct Implications for cultural orientations:

Schwartz' three bipolar value dimensions represent opposing responses to each problem [22]. Cultures display multiple values simultaneously [22]. While mastery and harmony do not dictate the end-state of the other two values, they do share complimentary and contradictory structures with the other four dimensions. The three dimensions can be crossed to reflect four basic cultural types (red and orange arches). Pairs of value types that are compatible are located in proximity going around the circle while pairs of value types that are in opposition emanate in opposing directions from the center [22]. Paired values combine to emphasize societal tendencies (arrow text).



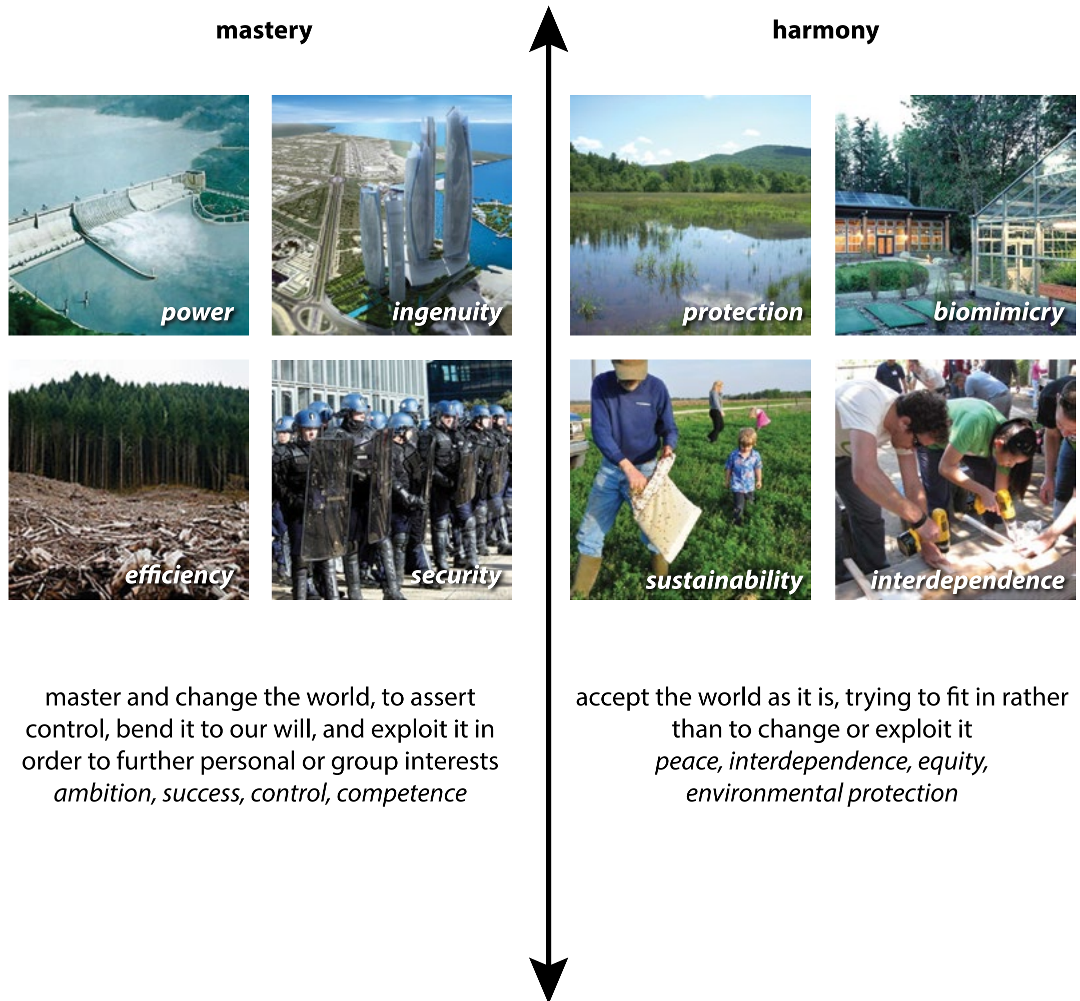


Figure A3.8 Social Values

Left hand photos and description represents a mastery social value trajectory for the Basin. The right hand photos and description represents a harmony social value trajectory for the Basin. [22 - descriptions]

Worldviews

A worldview corresponds to how individuals and society make sense of the world around them. Worldviews provide a framework for generating, sustaining and applying knowledge [37]. Worldviews go beyond values. Holling writes that worldviews are partial representations of reality, or myths that support a temporary certitude to direct policies and actions [38]. The key here is understanding that each view is incomplete, based on certain assumptions about stability, perceptions of processes, and prioritizations of appropriate policies [38]. The complexity and uncertainty of the natural and social environment leads to debate about how to interpret facts or trends. Worldviews articulate how people bend, or conform facts to make them consistent to their cultural outlook [39].

Past and Future: Worldviews are tied to both a temporal and geographic context, as well as community and spirituality, to industrialization and globalization. Our perception of nature and society has evolved over the last fifty years. The Civil Rights movement, the position of woman in the workforce, and the end of Apartheid in South Africa are all examples of how pervasive views of human equity have changed. Yet while we can track past changes, we are so entrenched in our own current worldviews that we cannot step outside our own biases and interpretations. In fifty years, different groups in the Snohomish Basin and the Puget Sound Region could be characterized by their divergent worldviews today. However, we cannot characterize our current worldview.

Worldviews are like caricatures of aspects of reality [38]. There is no 'right worldview' for where we are today, or where we are going, each caricature is incomplete. Holling describes these caricatures in terms of five myths of nature, and we map four of these myths onto the four scenarios, responding to the intersection between values and climate change [38].

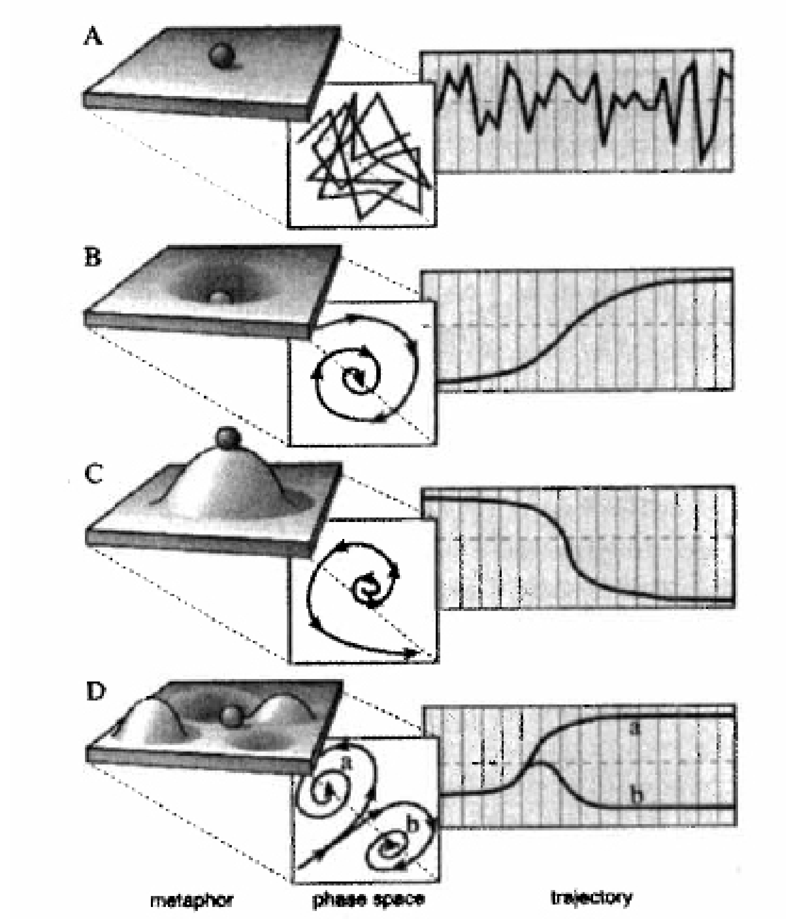


Figure A3. 9 Depictions of four myths of nature.

(A) Nature flat, (B) Nature Balanced, (c) Nature Anarchic, and (d) Nature Resilient. Each myth has three representations or metaphors: as stability landscape (left), phase diagram (center), and time course chart or trajectory of key system variables over time (right). [38]

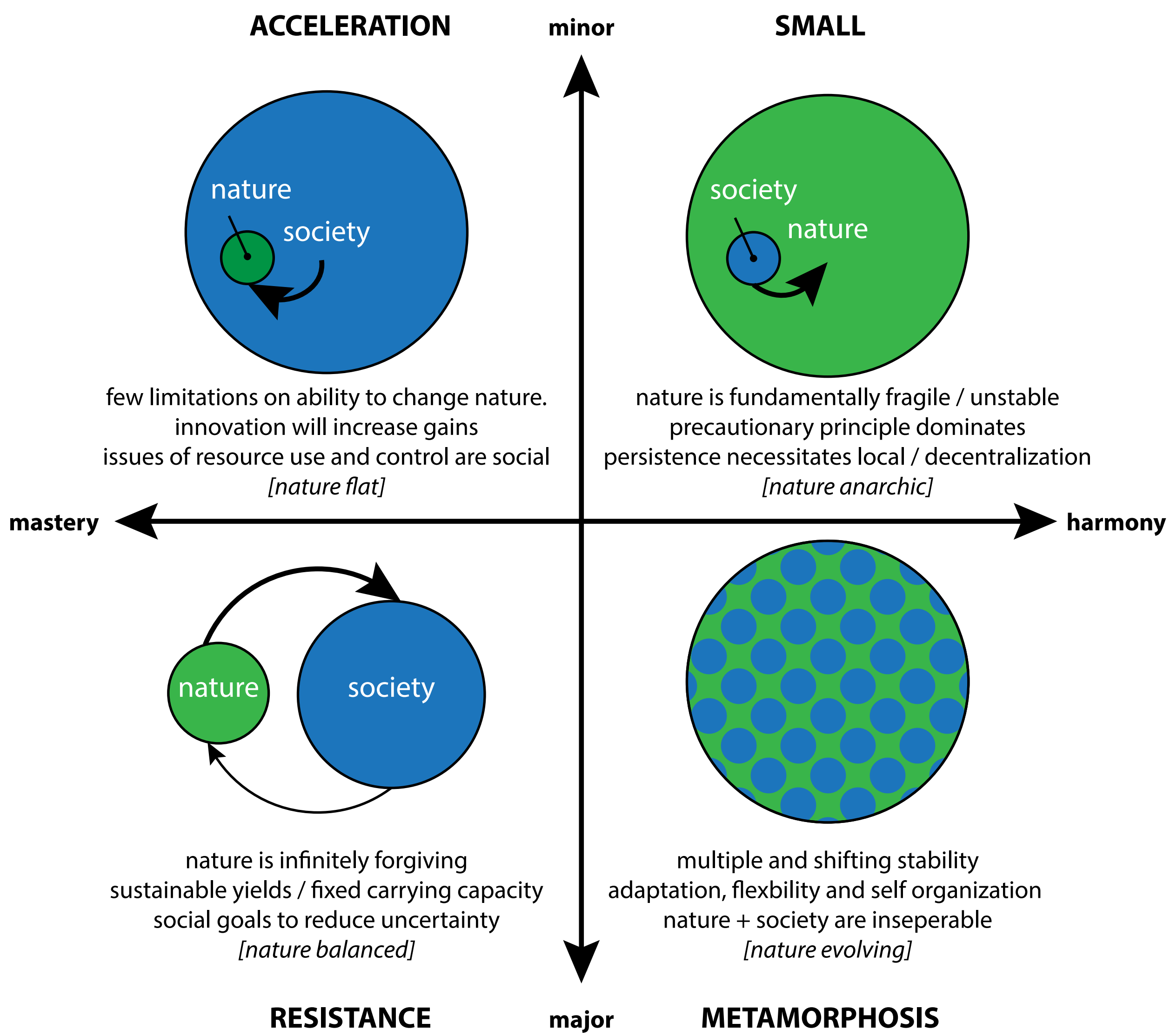


Figure A3.10 Worldviews under the four scenarios

Depictions of worldviews, or perceptions of the relationship between society and nature under the four scenarios in terms of 1) system stability 2) strategic approach and 3) driving perception / myth.

Governance

Governance, according to the World Bank, refers to the rules and rulers, and the various processes by which they are selected, defined and linked together [40]. Here, we refer to rulers as those jurisdictions, agencies, institutions, and elected officials that represent collective decision-makers. Rules are both the formally legislated regulations and the operational framework that dictate where and how funds are allocated. Governance translates dominant worldviews into legislated standards and practices that then get perpetuated through a community. While every community has diverse worldviews, it is the worldview of the voting majority or of those in power which are translated into law.

Past and Future: The Snohomish Basin is characterized by various scales of overlapping governments and approaches, including federal, state, local, and county jurisdictions shaping regulations from clean water standards to incentives and outreach. Over the last fifty years, many trends have been observed (though largely lacking quantitative data for validation) in the Region's governance. Key trends include 1) more decision-makers: from units of government to agencies and partnerships [15,41]; 2) more regulations: the number of enacted legislations on everything from overseeing funding allocations, anti-discrimination laws, and environmental permits has grown [41,42]; 3) greater size, complexity and inefficiency: while the funds and responsibilities allocated to governments have grown, as well as the operational complexity in terms of both factors and stakeholders to consider, there is increased skepticism about the efficiency of government in achieving results [41,43,44]. While some critics think government is too big, too controlling and too wasteful of public funds, others think government doesn't go far enough.

There are no predictive models forecasting how government will change in fifty years' time. While regional experts point to a continuation of trends,[41] it is likely the magnification of one trend over another that will hallmark new trajectories and critical thresholds of shifts in dominant paradigms and power holders.

Figure A3.11 Political boundaries in Snohomish Basin

The Snohomish Basin is bound by WRIA 7, a political boundary delineated by WA DOE. The Basin overlaps both Snohomish and King Counties including the City of Everett and over a dozen small towns and cities (gray). Basin lands also include the Tulalip Tribes and Snoqualmie Tribes as well as Federal and State lands (forest lands and wilderness areas, green).

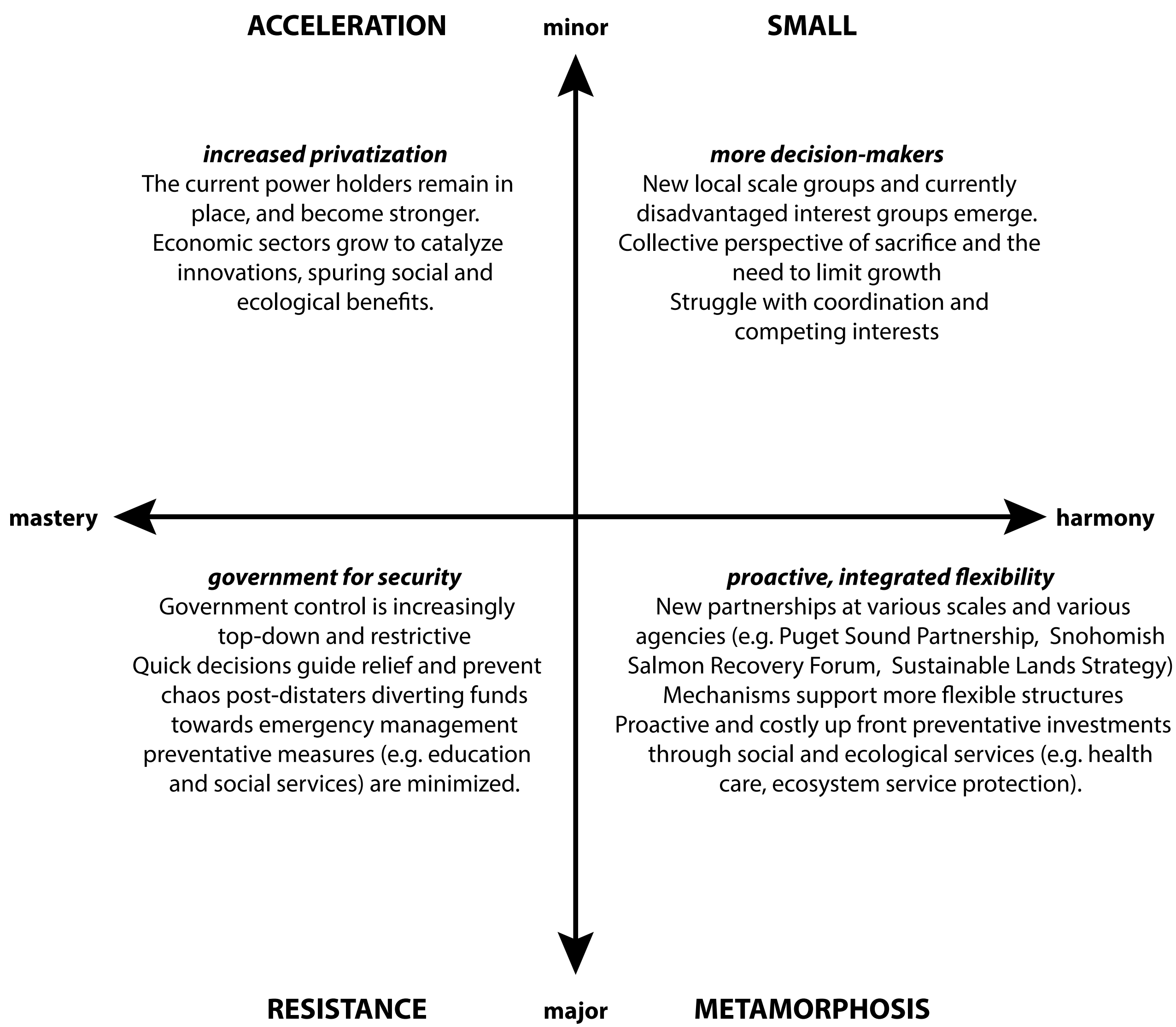


Figure A3.12 Governance trends under the four scenarios

Building on the aforementioned worldviews, as well as cultural values and climatic changes in the four scenarios, governance can be described by a focus on one or a handful of current trends [41].

Employment

Employment is here defined as both the number of jobs and their division along industry sectors representing segments of the economy. Different agencies split sectors differently; however four main groups dominate including primary raw material extraction like mining and farming, secondary refinement including construction and manufacturing, tertiary services like law and medicine and the distribution of manufactured goods, and quaternary knowledge activities including technological research, computer design, and biochemistry [45].

The total number of jobs is a major driver of in-migration as well as development pressure [46]. The growth of different industry sectors drives land use changes, resource demands, demographic changes and capital investments [47]. Job growth has direct implications for the magnitude of service needs (e.g. size of schools, size of roads), resource extraction (e.g. forestland conversions, water and energy demand) and waste streams (e.g. pollution, emissions, wastewater). Manufacturing necessitates different development patterns in terms of factories and transportation corridors compared to high-tech industry or farming [47]. Size of industry sectors correspond to labor characteristics, including educational attainment, age, and even ethnicity [48]. The rate of job growth has implications for governance, planning, and thresholds. For example, if job growth occurs very quickly we might exceed ecosystem thresholds before we have a chance to adapt. Important feedbacks influencing employment include availability of skilled workforce, supporting services (transportation infrastructure), regulatory predictability, and an attractive quality of life for employees [47].

Past and Future: Over the last 50 years, employment in King and Snohomish County has grown dramatically, more than doubling the total number of jobs between 1969 and 2009 [49]. However, while the rate of growth in King County jobs far exceeded the rate of population growth, the reverse can be said for Snohomish County [50]. King County increasingly became the employment center, while Snohomish grew as residential development. Over the past 50 years, the basin has changed from largely resource-based (timber, fishing and dairy farm) industries to manufacturing, technology and service-based industries (Boeing, health care) [51, 42,47,]. These trends are consistent in both King and Snohomish County and with the Clark Model of deindustrialization [47]. While the resource base has declined alongside declining resource lands and supportive infrastructure (e.g. mills), aerospace and Microsoft dominate the employment base and capital into the basin [47]. OFM's Input-Output model and PSRC's UrbanSim forecast jobs by sector out to 2040. The basin is forecasted to increase by an additional 150,000 jobs between 2010 and 2040. Fifty seven percent of those jobs will be in the financial, professional, business and educations sectors (including both tertiary service and quaternary knowledge activities) with construction and manufacturing jobs declining. Specifically, Redmond, Snohomish Valley and Marysville are forecasted to lose more than 15% of their manufacturing jobs, while East King County and Sisco Heights lose 30% of their construction jobs.

Long-term uncertainty in forecasts for the basin is predicated on global industry changes and competition, the cost of oil, economic markets, regional labor negotiations, research and innovation, and environmental restrictions [47]. The four scenarios explore potential growth rates in terms of total number of jobs and sectors based largely on the former drivers (climate, values, worldview and governance) [47].

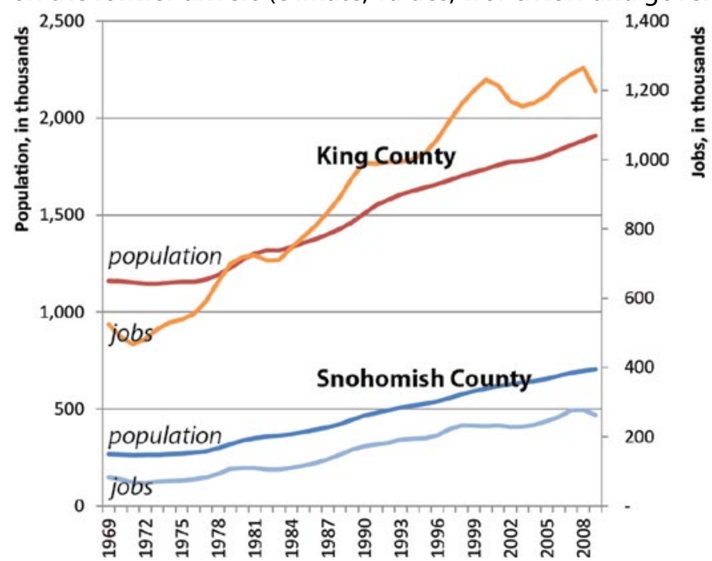


Figure A3. 13 Jobs and population in King and Snohomish Counties.

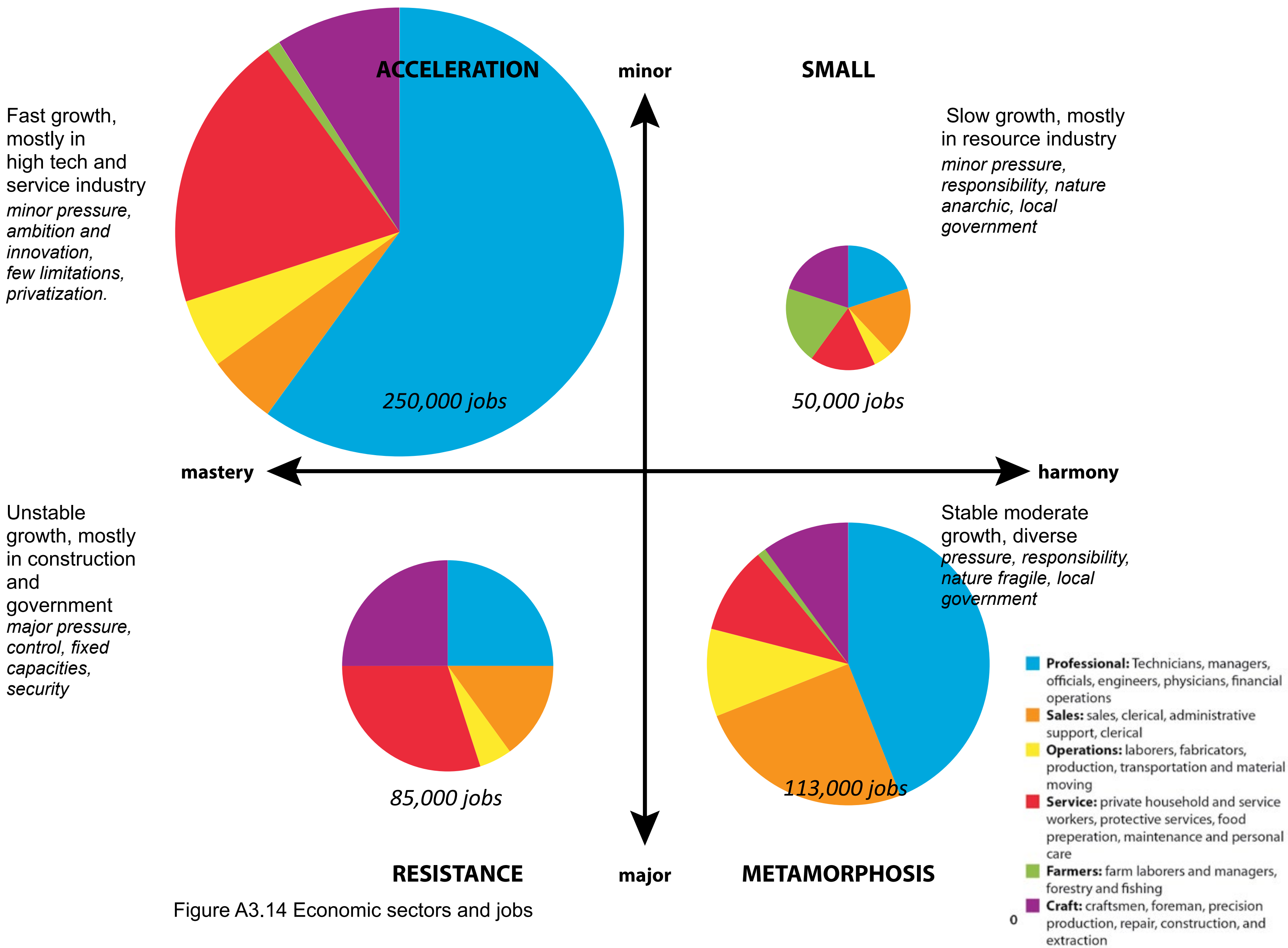


Figure A3.14 Economic sectors and jobs

Population Growth

Growth refers to the change in the number of people residing in an area. Population growth stems from both migration (in and out) and natural increase (birth rates and mortality) [51]. Demographic changes associated with changing population can be described in terms of age structure, ethnicity, household composition and size, and educational attainment [52]. Population growth is one of the most highly cited drivers of urbanization and environmental pressures [46, 47, 53]. The more people, the more development and services are required to serve that population [46,47,53]. While population growth can be distributed across the landscape in various spatial configurations and with variable demographic makeup, the larger the population growth the more water and energy consumed and the more waste produced. Demographic changes correspond to both legacy influences (e.g. current age and structure of the population) as well as in-migration and socio-economic changes [52].

Past and Future: Both Snohomish and King County have grown rapidly over the last 50 years, representing the fastest growing Counties in the State [54]. Birth rates, or fertility rates, have been pretty constant over the last couple of decades at ~13,000 additional people per year [54]. Changes in birth rates and mortality are associated with economic and cultural factors including health care, unwanted pregnancies, wealth and social norms (e.g. having children later in life or single parent households) [55]. While unwanted pregnancies and later first pregnancies have reduced fertility rates [56], medical science has conversely delayed death rates[76]. Historically, natural growth rates have stabilized, while migrations account for 96% of variability in the basin's population growth [54]. Jobs largely determine migration rates and the basin has seen growth in both high income residents working for high tech or green industry jobs, as well as Hispanic migrant workers associated with the agricultural community [46]. The basin's quality of life is considered an important factor in the decision to relocate (for both residents and employees) [47]. Significant changes such as replacement rates, or no growth scenarios, requiring government sanctions, are unlikely to occur in the basin.

Overall, there is almost unanimous agreement across experts and models that population will continue to grow over the next few decades [46, 47, 53, 15]. The Office of Financial Management and Puget Sound Regional Council have complimentary models to forecast and allocate future growth. OFM and PSRC Models describe declining population growth rates[3] with a 5% uncertainty band out to 2040, centered on an additional 210,000 people [52, 50]. Looking at past trends, it is forecasted that the basin population will continue to age (additional 9% of population over retirement age), and diversify (greater 6% non-white). Enrollment projection in 2 and 4 year colleges is projected to rise with growing population trends, dependent on age structures, budgets for higher education and economic opportunities [83].

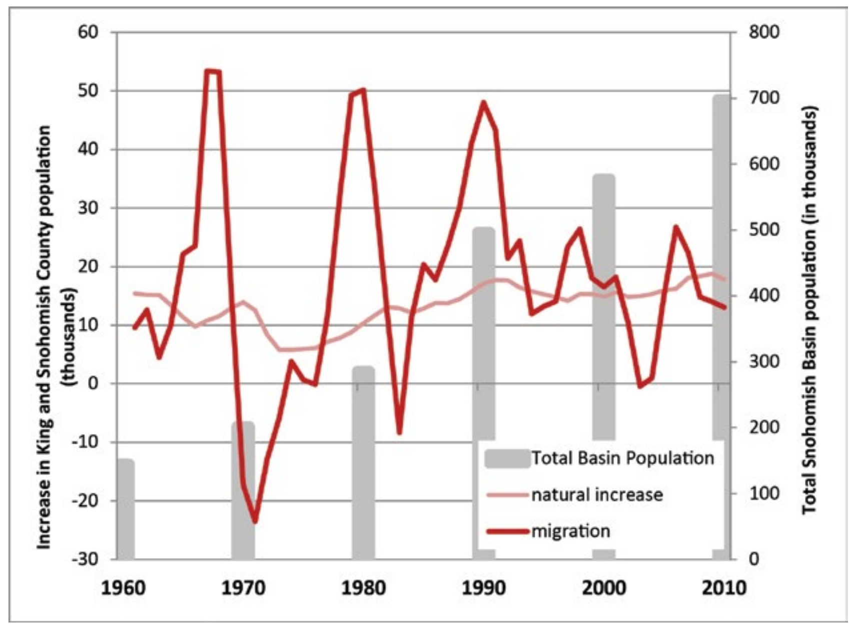


Figure A3.15 Population growth. Natural increase and migration.

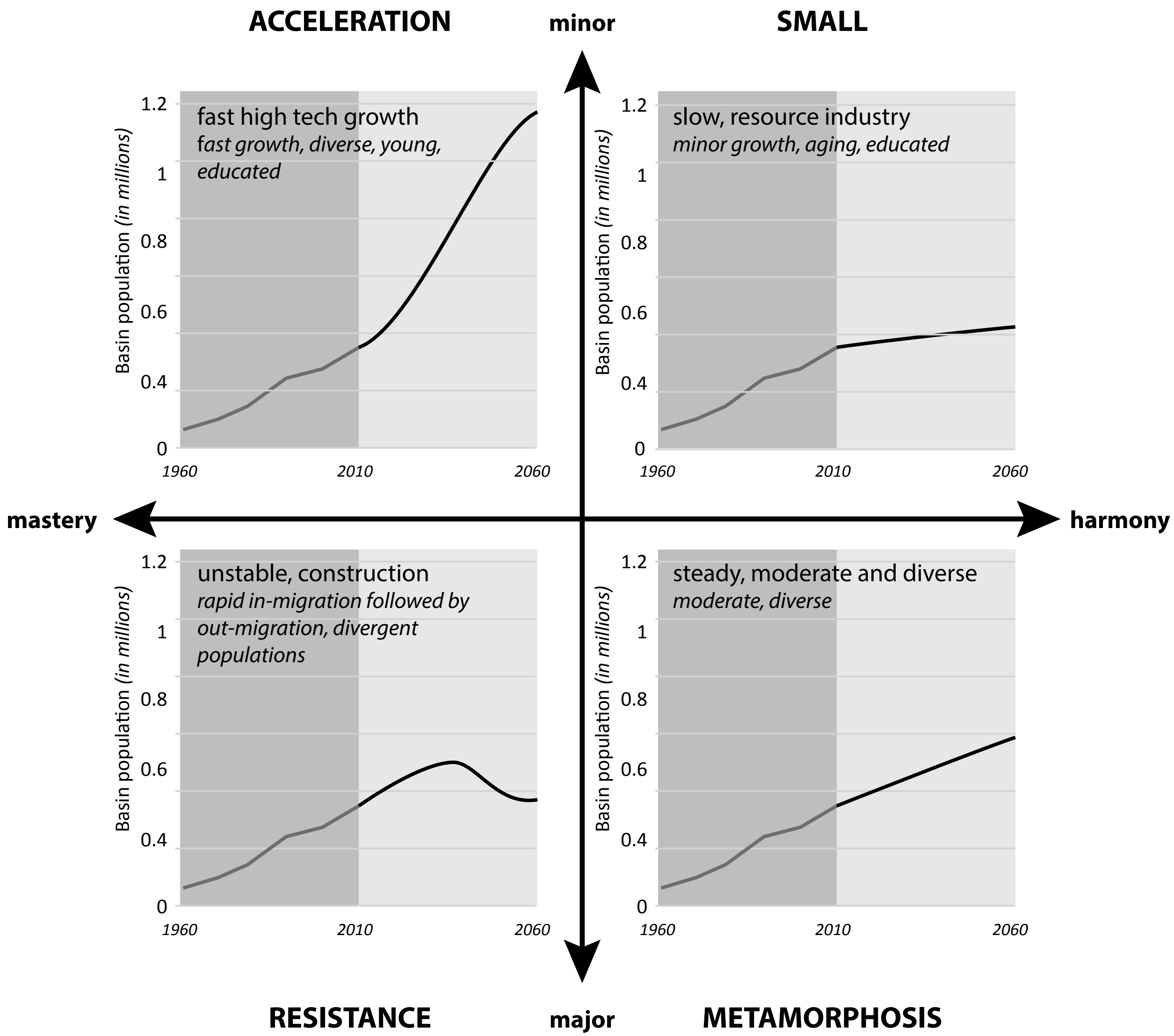


Figure A3.16 Population growth under the four scenarios

The four scenarios represent growth rates and demographic characteristics (ethnicity, age, and educational attainment) based on economic trends (growth and sectors)[94].

Wealth and Income

Wealth refers to the abundance of valuable possessions or money, while income is more specifically the amount of money earned in exchange for labor, services, or financial investments. Wealth can stem from various sources including inheritance and prudent savings; however growth in wealth is highly correlated to growth in income. Wealthier regions generally correspond to higher consumption levels [58] and educational attainment levels [58]. Of major importance is not only the level of wealth, but rather the distribution of wealth across an area [59]. Wealth and income disparities reflect the gap between the wealthiest and poorest members of a community. While gender and ethnic inequalities have declined (1960-2000), overall inequalities have grown since the 1970's, especially within the United States [60,61]. Recent publications contest that disparities are not simply borne of income growth, but rather distributional barriers, from taxation to regulations that systematically favor the top earners over the bottom earners [62]. Greater disparities have major implications on health, security, environmental equity and civil rights.

Past and Future Trends: As basin industry shifted from resources to services, the level of personal wealth in the basin rose substantially [63]. Today the basin is characterized by higher shares of disposable income affecting land use decisions, like the rise of 'ranchettes' and very large residential homes [42,53] . However, the growth in income cannot be singularly depicted as negative environmental change; for example, the Tulalip Tribes have seen a marked shift in wealth with the opening of the Resort and Casino, which has enabled a cash infusion allowing for longer term investments in natural and human resources [15]. The basin continues to house lower income households, and while suburban residential neighborhoods reflect lower income disparities [64], the overall gap between the wealthy and poor populations in the basin is widening. In general, increasing urbanization has been linked to increasing wealth disparities, barring a fundamental shift in distribution (e.g. socialism) [41]. Future challenges associated with disparities in the basin include poverty, privatization of service provision and segregation [41]. Poverty issues include homelessness, employment instability, overcrowding and lack of health care access [65]. Privatization of currently public services, from roads, schools, recreation, may exacerbate environmental and health inequities [41].

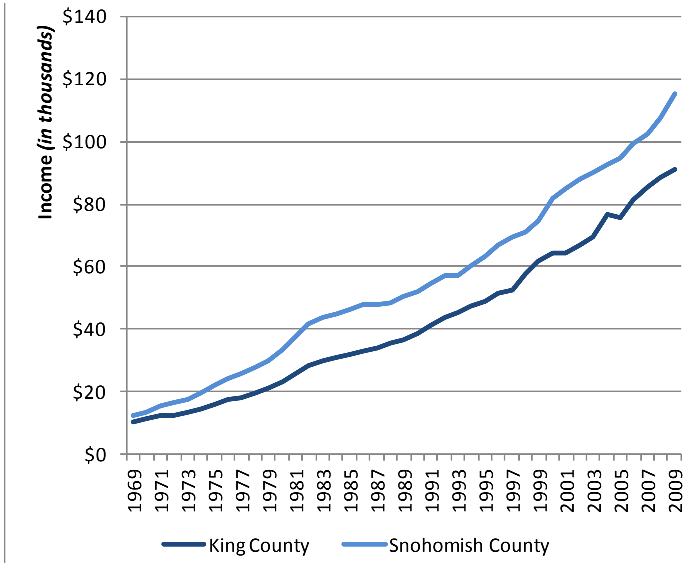


Figure A3.17 Income growth 1969-2009.[69]

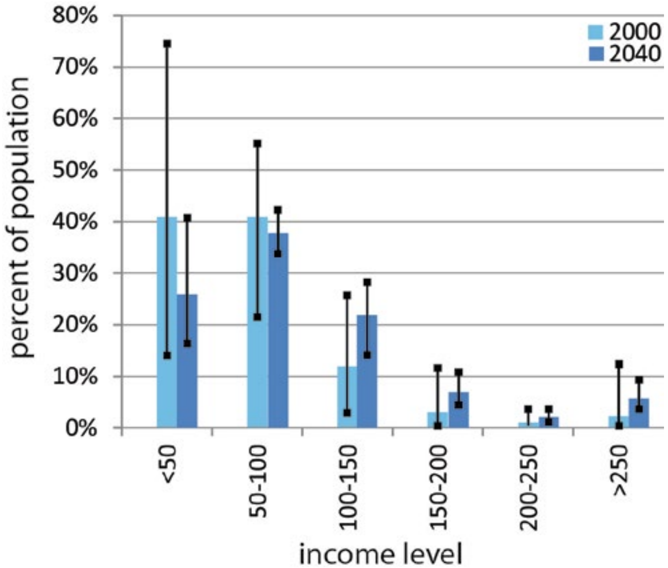


Figure A3.18 PSRC Snohomish Basin forecasted income disparity [50]

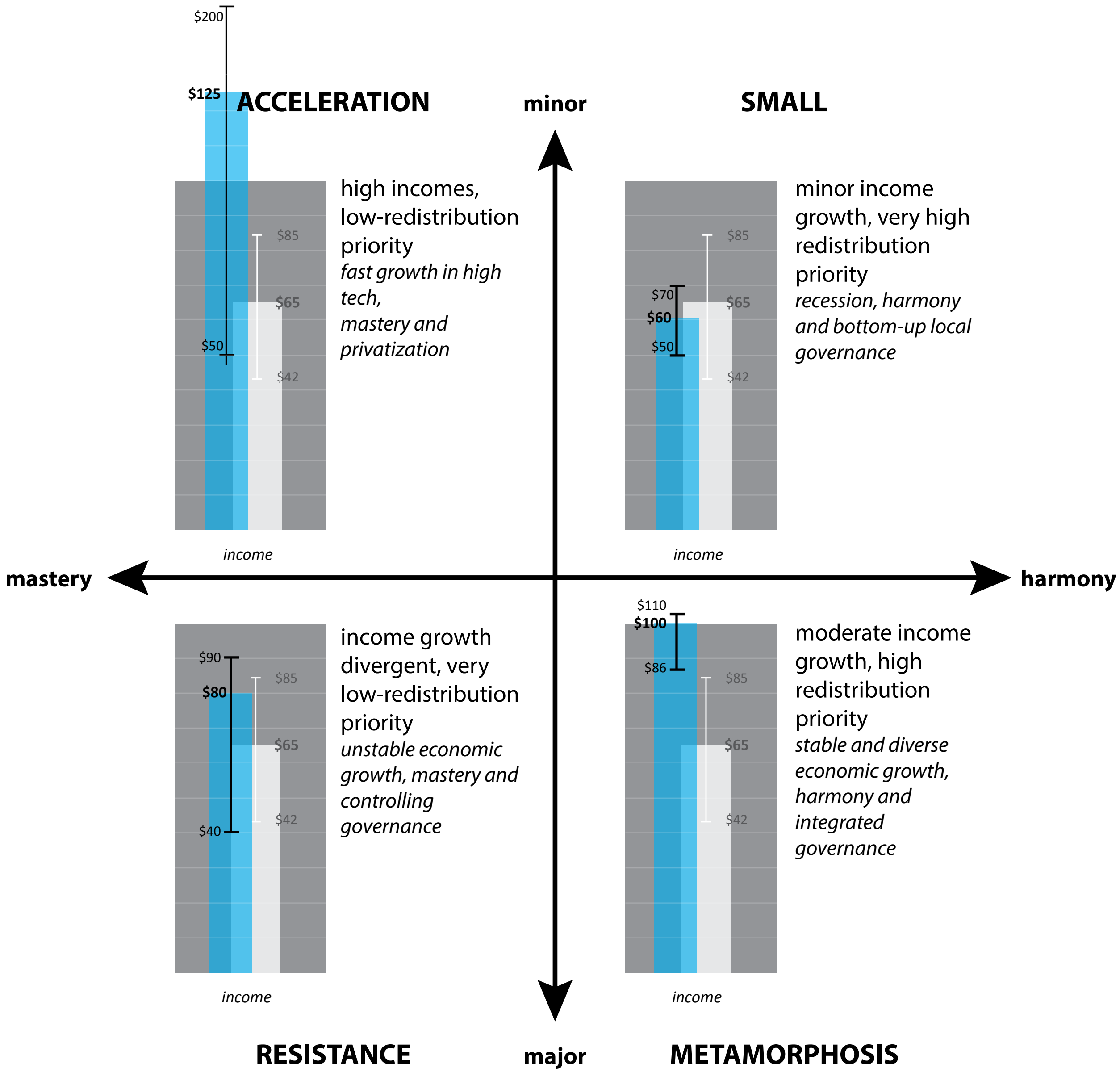


Figure A3.19 PSRC Snohomish Basin forecasted income growth and disparity

Development

Development describes the settlement pattern on the landscape and changes in both land use and cover. Economic growth largely drives development; the higher the demand for new homes, factories, stores, golf courses - the greater the conversion of current lands. However development is restricted to varying degrees by regulations, market preferences and infrastructure capacity [53]. Regulations, such as zoning or the Growth Management Act (GMA) direct the location and type of growth permitted [53]. Market preferences reflect new trends, whether for larger garages, greater densities, more flexible space, or access to services and utilities [66]. Infrastructure capacity, including water, waste, roads and industrial support, from mills to telecommunication cables, influence development [41,53].

The implications of development reflect one of the greatest and most cited sets of opportunities and challenges for economic, social and environmental systems [44,53,67,68]. Economically, development in terms of rate, magnitude and shape translate into a positive feedback to greater economic growth, resulting in construction activity, service jobs to support the new population, and greater demands on goods and services [69]. Socially, the character of development and disparities between adjacent neighborhoods leads to shifts in demographic profiles, community growth, affordability and equity challenges. In terms of environmental implications, development is linked to everything from impervious surfaces changing infiltration and drainage pathways, habitat conversion and fragmentation, the spread of invasive species, to vehicle emissions and runoff pollution [70].

Past and Future: The last fifty years has brought unprecedented development in the form of 'urbanization' into the basin. The rural landscape characterized by small resource based towns, working forests and farms and community cooperation is rapidly being converted to 2-5 acre homes, with a preference for urban amenities including parks, high tech employment and proximity to services [42, 71-74]. Over the last fifty years the basin has grown by 38-50% every decade[4]. Between 1972 and 2006 the basin grew by over 20,000 acres of urban land [75]. Today over 120,000 housing units are spread across more than 50,000 acres of urban development [76] and 2,400 miles of roads [77]. Twenty eight percent of the basin's households are outside of urban growth areas [78]. While the rate of building permits and new development has slowed down with the recent economic downturn [79], the last 20 years have exhibited some of the fastest growth rates in the State [50]. An important uncertainty is changing household size; for the past 30 years household size has declined, the rate of decline has nearly flattened over the last decade, with the potential of significantly reducing the number of forecasted housing units [53].

While future development patterns are highly uncertain, the overall drivers behind change are likely indicative of current drivers including economic pressures (how much growth we need to accommodate) market values (preferences for specific character and density of buildings), regulation (in terms of strength and effectiveness) and infrastructure limitations (traffic congestion, water withdrawals) [53].

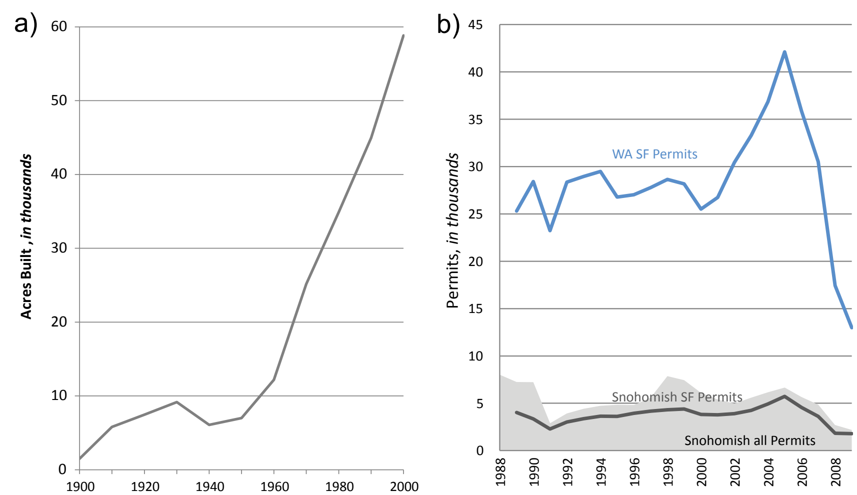


Figure A3.20 (a)Acres developed by decade. (b) Building permits 1988-2008 at the State and Snohomish County level.

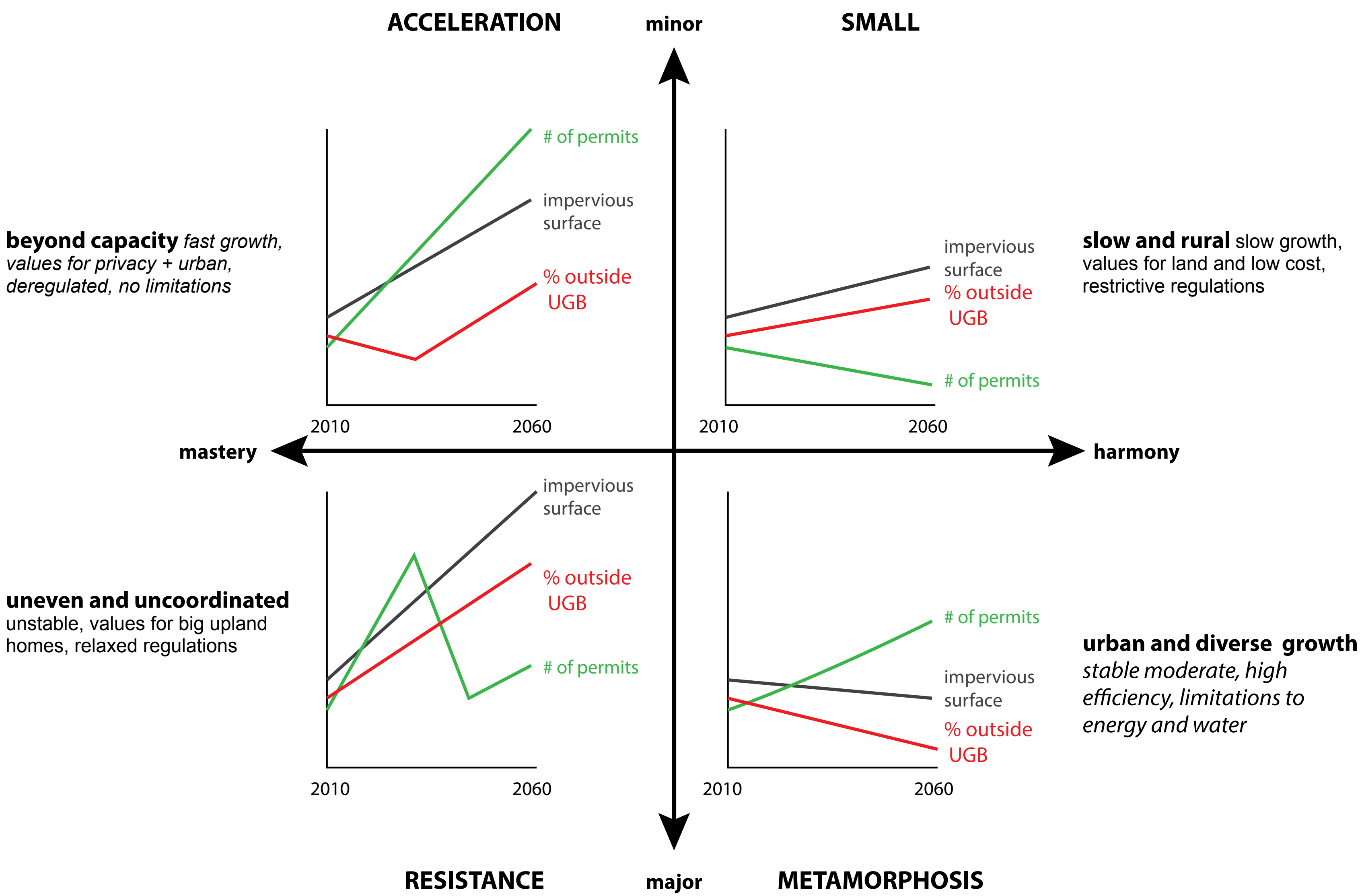


Figure A3.21 Future Development Trends:
The four scenarios can be described in terms of three development characteristics: 1) Footprint of development (i.e. total acres of impervious area), 2) Rate of development (i.e. rate of building permits for single and multiple family homes), and 3) Shape and density (i.e. % of new development outside UGA).

Investments

An investment involves the choice by an individual or an organization to commit money for the purchase of assets for the possibility of generating returns over a period of time [80], but with the awareness of a certain level of risk [81]. What we choose to invest in or 'where the money goes' has important implications to infrastructure and service provision over the long term in the Snohomish Basin. Further, higher levels of services may function as a growth magnet, attracting new development into an area, necessitating greater investments, and so forth [53,47]. Infrastructure refers to the technical structures that support a society [82], such as roads, water supply, sewers, electrical grids, and telecommunications lines. Services refers to those benefits that facilitate the health and safety of a population, including but not limited to social services, education, fire control, hospitals, police, parks and recreation.

Government, supported through taxes, has the role of ensuring adequate infrastructure and services to its population. However, social preferences, economic growth, technological innovations, and the availability of natural resources influence investments committed. Investments can be categorized by the amount (dollars) invested, approval or level of service garnered, where the investment is allocated (roads or rivers, businesses or health), the type of investments (engineered vs. natural, market-based vs. progressive) the discount rate (short vs. long term), and several other metrics.

Past and Future: There are various sources of investments supporting the Snohomish Basin, from federal agencies (federal highways), to local areas (Snoqualmie Water District), and private organizations (Puget Sound Energy). The basin's abundance of resources, from open lands to water for drinking and hydroelectricity has traditionally facilitated inexpensive and rapid infrastructure provision [68]. In recent decades, shortfalls have occurred as the area's growth rate exceeded the capacity of existing infrastructure, leading to traffic congestion, moratoriums for sewage hook-ups, and explorations for long term alternative energy provision and water withdrawals [68, 5, 83,84,53]. Public service provision has also strained small municipality budgets as revenue demanding residential development exceeded revenue building commercial growth [41].

Over the last fifty years, regulations and oversight governing infrastructure and services has risen significantly [41,42,47]. From NEPA requirements, to Citizen Review Boards, the legwork required to put in a new wastewater facilities, roads, health clinics or schools, all have extended the time and cost for implementation by public and private organizations alike [41,42,47]. On one hand, there is far greater accountability for civil rights, environmental protection, hazardous risks, and fiscal responsibility [85]. On the other hand, transformative undertakings, like the Culmback Dam, or Interstate 5, are unlikely to be supported in the near future [68,72]. Oversight costs trickle down from federal and state levels to private homeowner investments; the permits required to drain a field, add a garage to your home, or thin a forest have all grown significantly [41,42].

Technological innovations over the last fifty years are largely responsible for transforming the approach and distribution of infrastructure and service investments. Think only about the role of computers today, in everything from accessing public records to monitoring water use, to imagine the evolution. The basin infrastructure and services are now better connected to global markets and individual rural households [41,42,47]. Technology has increased the efficiency of infrastructure in terms of energy and water use [68], but also in terms of human power required[128]. Service and infrastructure provision jobs have shifted from being more human and mechanical to being technical [42]. Today's investments prioritize electronic access to government files [41] and satellite imagery to improve transportation corridors over additional agency personal and road building[72].

ACCELERATION — minor — **SMALL**

Regional Private Innovations

Rapid growth in capita > extensive regional investments
Focus on innovation > cutting-edge technologies to solve critical challenges
Privatization > shift actors providing services and influencing risks and benefits from investments.

Neighborhood Green Solutions

Long-term recession > halt funds for regional investments
Focus on local scale challenges > 'off-grid' solutions at a community / neighborhood level.
Long-term social / environmental responsibility > low-risk, carefully monitored investments.

mastery ⟷ **harmony**

Immediate Public Security

Climate and hydrological disasters > focus on infrastrucure to withstand abrupt change in the short term.
Security > defense, and reduction of variability.
Social disparities in wealth and access > parallel but unequal systems for support.

Network of Experiments

Harmony values > investments in natural capital allow change through buffers, flexibility and adaptive capacity
Economic stability > long term proactive investments
Novel environmental conditions > diversity of monitored integrated experiments.

RESISTANCE — major — **METAMORPHOSIS**

Figure A3.22 Investments under the four scenarios

Above scenarios depict how basin trends in governance, social preferences, economic growth, technological innovations, and the availability of natural resources might influence investment patterns.

Resource Management

Resource Management refers to the management of materials or substances such as minerals, forests, water, and fertile lands that occur in nature. The basin's abundant resources are characterized by a long history of management and extraction [71], which today is largely focused on urbanization pressures, environmental regulations and the legacies of past decisions. Resource management in the basin can largely be divided into agriculture in the lowlands, forestry in the mid to higher elevations, and recreation, largely focused in the higher elevation wilderness areas. While each of these resources is challenged by unique economic and ecological pressures, all three have in common their ability to support both social and ecological benefits that go beyond financial benefits.

Past and Future: Agriculture refers to the activity or business of growing crops and raising livestock. While a for-profit business, agriculture is intricately tied to food security, cultural heritage and wildlife habitat, among numerous other benefits [42,15]. The face of farming in the basin is changing. While the basin has a deep history in dairy farming (e.g. Carnation), today the basin boasts diverse crops and livestock farms, with a niche for direct-marketing and organic goods, as well as high-commodity specialty crops and hobby farms [42]. At a County level, King and Snohomish each bring in about $150 million a year from agriculture [68], supporting 1,500 [87][6] farms over 50,000 acres [88]. While the total acres of farms and total gross product have declined with associated urbanization pressures [89], the number of farms has grown [89]. The first farms in the basin removed lowland forests and dramatically altered the floodplain in terms of habitat and flow [71]. In recent years, the largest challenge for lowland farms has been flooding and restricting regulations around drainage [42]. While climate change, urbanization, public support for local food, and wildlife species protection are among the most important drivers influencing the future of agriculture in the basin, the challenges and opportunities associated with living on a floodplain will likely continue to dominate agricultural debates [42].

Forestry[5] is the science of planting and caring for forests and the management of growing timber and other valued forest products [90]. As with agriculture, the viability forestry is dependent on market values, cost of operations, regulations, and the opportunity cost of residential development [73]. Historically, the timber industry was the public face of the Snohomish Basin – with the Snoqualmie Mill and Weyerhaeuser [71]. However, several factors, including environmental regulations (e.g. Spotted Owl), urbanization pressures, globalization, closure of mills, and the purchase of Wilderness Areas, have led to the slow decline of forestry in the basin [73]. Today's working forests reflect a patchwork of public (USFS), private (both large and small) and NGOs owners with diverse management objectives and strategies [73]. Of the basin's 920,000 acres of deciduous and coniferous forests [91], approximately 300,000 acres are actively managed [92]. Between 1986 and 2007 the basin lost over 220,000 acres of forests [93]. Future forestry decisions will be constrained by current influences including available infrastructure, regulation costs, ecological damages (e.g. landslides) and market values [73]. In addition, climate change will likely influence forest management through shifts in energy and water limitations [17], disease and fire risks [17], regulations governing carbon stocks and fluxes [94], and shifts in human values around management along the urban-rural fringe [73,74].

Recreation can refer to any leisure activity, but here we specifically focus on outdoor recreation, including but not limited to skiing, hiking, climbing, fishing, camping, biking, ATV, bird and nature watching, swimming, and hunting. Currently, the basin supports 638,000 [95] acres of public recreation lands, nearly over half of which are (301,000 acres) are dedicated Federal Wilderness Areas[6]. Today, there are 1.45 acres / capita in the basin[7]; however this boundary is an ineffective parameter as basin recreation lands support a much larger regional population, including not only the City of Seattle, but in fact State-wide and even national visitors [74]. Further, contiguous Wilderness Lands expand far beyond the boundary of WRIA 7 (538,275 acres[8]). Urbanization has simultaneously increased access pressures on recreation lands (both in terms of visitors but also challenges at the wildland interface) and heightened opportunities for advocacy and volunteering (e.g. trail maintenance and invasive weed pulling)[74]. In addition to urbanization, future pressures will likely include new forms of recreation, technological innovations, higher gas prices, climate changes and funding sources [74].

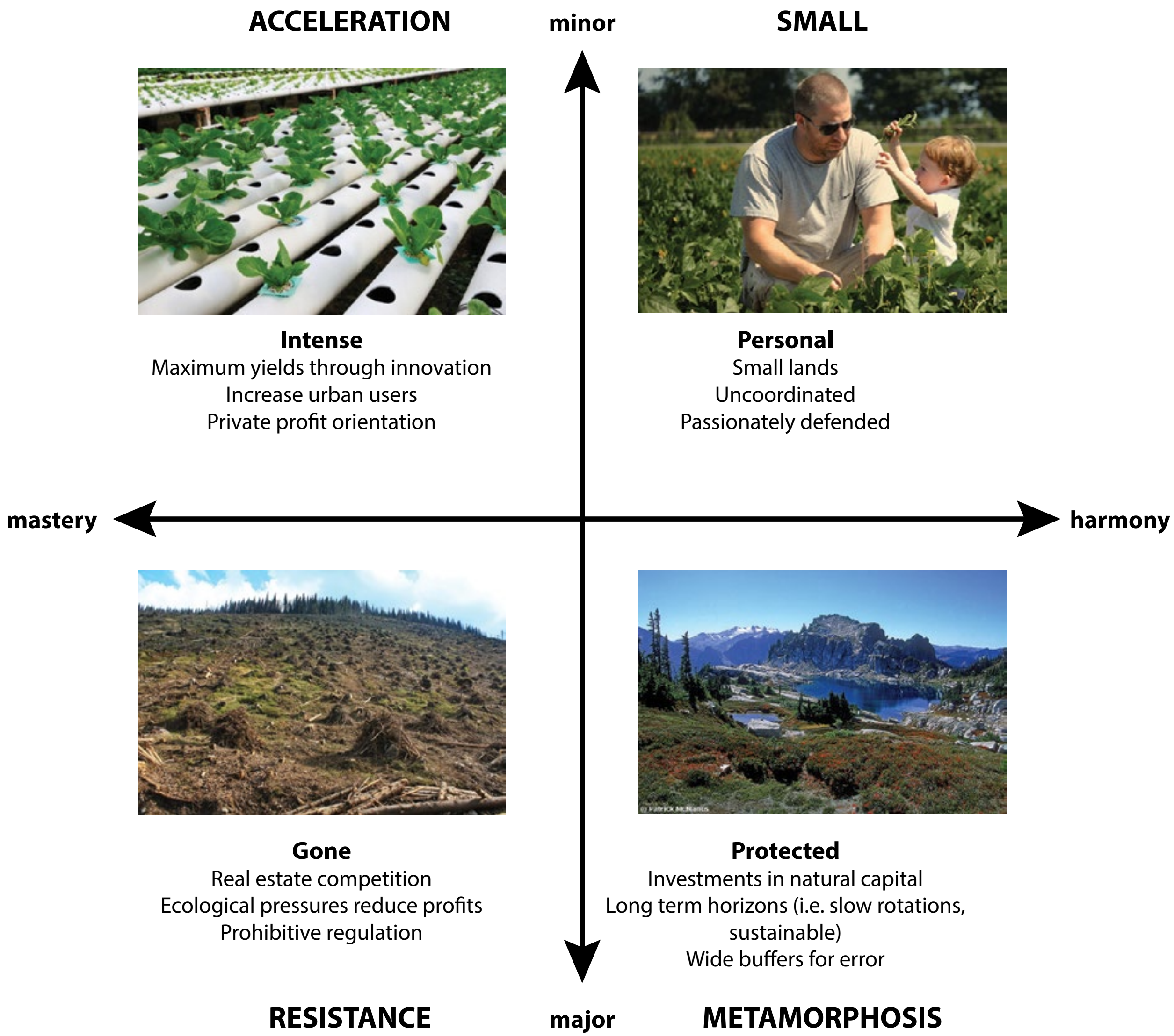


Figure A3.23 Resource use under the four scenarios

Notes

1. The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts. The UN General Assembly endorsed the action by WMO and UNEP in jointly establishing the IPCC".IPCC website: home, last accessed 04.20.12 http://www.ipcc.ch/organization/organization.shtml#.T5luR7PZ5Yw

2. Mastery and Harmony were selected as 'the most important and uncertain social value dimensions' by a selected subset of the Science Team during the Scenario Development Meeting, August 2011.

3. Rates are dependent on the level of spatial aggregates (i.e. Census block, forecast Analysis Zone, County).

4. Comparing total impervious area based on parcel level year built data within the Snohomish Basin for 1960, 1970, 1980, 1990 and 2000.

5. Forestry, timber, active, or working forest lands all reflect a specific land use, while forests overall refer to a land cover.

6. Including acreage for Alpine Lakes, Wild Sky and Henry Jackson Areas within the boundary of WRIA 7. There are 458,000acres of Federally owned lands, and 147,000 State owned lands in the Basin in total.

7. Major Public lands acreage divided by 2010 Census tract population within WRIA 7.

8. Combination of Alpine Lakes, Wild Sky, Henry Jackson and Glacier Peak.

References Cites

1. Intergovernmental Panel on Climate Change (IPCC), 2007. Climate Change 2007: The Physical Science Basis. Working Group I Fourth Assessment Report: Summary for Policymakers. http://www.slvwd.com/agendas/Full/2007/06-07-07/Item%2010b.pdf

2. Snover, A. K., P. W. Mote, L. Whitely Binder, A.F. Hamlet, and N. J. Mantua. 2005. Uncertain Future: Climate Change and its Effects on Puget Sound. A report for the Puget Sound Action Team by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle).

3. America's Climate Choices. National Research Council. 2011.

4. Intergovernmental Panel on Climate Change (IPCC), 2007. Climate Change 2007: The Physical Science Basis. Working Group I Fourth Assessment Report: Summary for Policymakers. http://www.slvwd.com/agendas/Full/2007/06-07-07/Item%2010b.pdf

5. Water Supply Forum. 2009. Regional Water Supply Outlook. http://www.watersupplyforum.org/home/outlook/. Last Accessed March 2013.

6. Salathé Jr, E.P., Y. Zhang, L.R. Leung, Y. Qian, 2009. Regional Climate Model Projections for the State of Washington. Climatic Change, in press. http://www.atmos.washington.edu/~salathe/papers/Salathe_et_al_2009_RCM_cc.pdf

7. Mote, P., Hamlet, A., and Salathé, E. 2008: Has spring snowpack declined in the Washington Cascades? Hydrol. Earth Syst. Sci., 12, 193-206. http://www.atmos.washington.edu/~salathe/papers/MoteHamletSalathe_HESS.pdf

8. Y Zhang, V Dulière, P Mote, EP Salathé 2009: Evaluation of WRF and HadRM Mesoscale Climate Simulations over the United States Pacific Northwest. J. Climate, 22. http://www.atmos.washington.edu/~salathe/papers/Zhang_20090429.pdf

9. Fisher, B. and Nakicenovic, N., Chapter 3: Issues related to mitigation in the long-term context, Section 3.1: Emissions scenarios: Issues related to mitigation in the long term context in IPCC AR4 WG3 2007.

10. Interview with Climate Impacts Group, 2012.

11. Climate Impacts Group Website. 2011.

12. Katz, R. W., & Brown, B. G. (July 01, 1992). Extreme events in a changing climate: Variability is more important than averages. Climatic Change, 21, 3, 289-302.

13. Mote, P.W., 2003: Twentieth-century fluctuations and trends in temperature, precipitation, and mountain snowpack in the Puget Sound/Georgia Basin region, Canadian Water Resources Journal, 28, 567–586.

14. Miriam Webster online dictionary. Snowpack definition. Last accessed 04.20.12

15. Interview with Tulalip Tribes, 2011

16. Interview with Physical Scientists Group, 2010.

17. Climate Impacts Group, 2009. The Washington Climate Change Impacts Assessment (WCCIA), M. McGuire Elsner, J. Littell, and L Whitely Binder (eds). Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle, Washington. Available at: http://www.cses.washington.edu/db/pdf/wacciareport681.pdf

18. Hamlet, A.F. 2011. Quantifying the Effects of Climate Variability and Change on Hydrologic Extremes in the Pacific Northwest. Pacific Climate Impacts Consortium. http://pacificclimate.org/seminar/2011/quantifying-effects-climate-variability-and-change-hydrologic-extremes-pacific-northwes.

19. Interview with Basin Ecologist, 2010

20. Schwartz , S.H. and Bilsky, W. 1987. 'Towards a universal psychological structure of human values', Journal of Personality and Social Psychology, 53.550-562.

21. Bardi and Schwartz. Values and Behavior: Strength and Structure of Relations. http://psp.sagepub.com/content/29/10/1207.full.pdf

22. Schwartz, S.H. 1999. A Theory of Cultural Values and Some Implications for Work. APPLIED PSYCHOLOGY: AN INTERNATIONAL REVIEW,48(1). P23-47. http://www.sjsu.edu/people/sharon.glazer/courses/psyc190/s1/Schwartz%201999.pdf

23. Schwartz, S. H., Melech, G., Lehmann, A., Burgess, S., and Harris, M. (2001), 'Extending the cross-cultural validity of the theory of basic human values with a different method of measurement', Journal of Cross Cultural Psychology, 32, pp. 519–542.

24. Inglehart, R. (1977). The silent revolution: Changing values and political styles among Western publics. Princeton, N.J: Princeton University Press.

25. Inglehart, R. (1991). Cultural changes in advanced industrial societies: Predictions and findings. Leiden: Universiteit Leiden, Faculteit der Sociale Wetenschappen.

26. Triandis, H. C. (February 01, 1991). COMMENTS ON WORK CENTRALITY AND WORK MEANINGS. European Work & Organizational Psychologist, 1.

27. Hofstede, G. H. (1980). Culture's consequences: International differences in work-related values. Beverly Hills, Calif: Sage Publications.

28. Bourdieu, P. (1972). Outline of a theory of practice. Cambridge: Cambridge University Press.

29. Kitayama, S., Markus, H., & International Conference on Emotion and Culture. (1994).Emotion and culture: Empirical studies of mutual influence. Washington, DC: American Psychological Association.

30. Schwartz, S. H. (1994). Are there universal aspects in the content and structure of values? Journal of Social Issues, 50, 19-45.

31. Schwartz, S.H. 2006. Value Dimensions of Culture and National Difference. The Hebrew University of Jerusalem, Israel. http://www.uib.no/psyfa/isp/diversity/content/reseach/multicultur/Workshop/Schwartz%20.pdf

32. MacTruk, R.H. and Morgan G.A. Mastery Motivation: Origins, Conceptualizations and Applications. 1995

33. Schultz, P.W. and Zelezny, L. 2003. Reframing Environmental Messages to be Congruent with American Values Research in Human Ecology

34. Hofstede, G. Culture's Consequences: Comparing Values, Behaviors, Institutions and Organizations Across Nations. 2nd Edition, Thousand Oaks CA: Sage Publications, 2001

35. Hitlin and Pilivin. 2004. Values: Reviving a Dormant Concept. Annu. Rev. Sociol. 30:359-93.

36. Interview with Human Perceptions and Behavior Group, 2010-2012.

37. Wikipedia. Worldview definition. Last Accessed 4.20.12

38. C.S. Holling, L.H. Gunderson and D. Ludwig. 2001. Panarchy: Understanding transformations in Human and Natural Systems. Island Press. p10.

39. Joyce, C. 2012. Belief in Climate Change Hinges on Worldview. 4.26.12. http://www.npr.org/templates/story/story.php?storyId=124008307

40. The World Bank. 2011. What is Governance? Arriving at a common understanding of Governance. http://go.worldbank.org/G2CHLXX0Q0. Last Accessed 04.20.12

41. Interview with Governance Group, 2010.

42. Interview with Agriculture Group, 2010

43. Interview with County Planning Department, 2010.

44. Interview with Restoration and Ecosystem Health Group, 2010

45. Wikipedia. Industry: Industrial Sectors, definition. Last Accessed 04.20.12.

46. Interview with Demographic Group, 2011.

47. Interview with Economic Group, 2010.

48. OFM, 2011. The 2002 Washington Input-Output Model. http://www.ofm.wa.gov/economy/io/2002/default.asp

49. Bureau of Economic Analysis. 2012. Personal Income Statistics by County. http://www.bea.gov/

50. PSRC, 2012 Puget Sound Economic and Demographic Forecasting: 2006 Puget Sound Economic and Demographic Forecast. Last Accessed 04.20.12.

51. Census Industry Sectors, 1960, 1970, 1980, 1990 and 2000

52. OFM, 2011. Forecast of the State Population by Age and Sex: 2000 to 2040.

53. Interview with Growth Management Group, 2012

54. OFM, Historical census data: Decennial population counts for the state, counties, and cities: 1890 to 2000. Last Accessed 04.20.12.

55. OFM, 2010. Population Change: Natural Increase and Net Migration.

56. Sightline Institute. Ensure Every Child is Wanted. Last Accessed 04.20.12

57. OFM, 2009. Higher Education Trends and Highlights: State-funded enrollment in Washington's public Higher education system. http://www.ofm.wa.gov/hied/highlights/highlights.pdfLast Accessed 04.20.12.

58. Pearce, F. 2009. Consumption Dwarfs Population as Main Environmental Threat. Yale Environment 360: Opinion, Analysis, Reporting and Debate. http://e360.yale.edu/feature/consumption_dwarfs_population_as_main_environmental_threat/2140/

59. Spilerman, S. 2000. Wealth and Stratification Processes. Annual Review Sociology. 26:497-524.

60. Wolff, E.N. 2007. Recent Trends in Household Wealth in the United States: Rising Debt and the Middle-Class Squeeze. The Levy Economics Institute of Bard College. July 2007.http://www.levyinstitute.org/pubs/wp_502.pdf.; Wolff, Edward N. 1987. "Trends in Household Wealth in

the United States, 1962–1983 and 1983–1989." Review of Income and Wealth 40(2): 143–174

61. Krugman, Paul. 2009. Huffington Post. http://www.huffingtonpost.com/2009/08/14/income-inequality-is-at-a_n_259516.html. posted 09/14/2009. Last Accessed 04/20.12.

62. Ayers, I. and Edlin, A. S. 2011. Don't Tax the Rich. Tax Inequality itself. http://www.nytimes.com/2011/12/19/opinion/dont-tax-the-rich-tax-inequality-itself.html. posted 12.18.11. Last Accessed 04/20/12.

63. Census household income and industry sector, 1960m 1970, 1980, 1990 and 2000.

64. Morrill, D. 2011. Income, language, education: Puget sound region is a rich mix. Cross cut: News of the Great Nearby.

65. Interviews with Social Services Group, 2010.

66. Interviews with Real Estate Group, 2010.

67. Interviews with Biological Scientists, 2010

68. Interviews with Water and Energy Group, 2010.

69. OFM. 2011. Washington Trends. http://www.ofm.wa.gov/trends/

70. Alberti, M. and J.M. Marzluff. (2004). Ecological resilience in urban ecosystems: Linking urban= patterns to human and ecological functions. Urban Ecosystems 7:241-265; Alberti, M. 2005. The Effects of Urban Patterns on Ecosystem Function International Regional Science Review. 28:2. P168-192.

71. Interview with David Dilgard, City of Everett Historian.

72. Interview with Infrastructure Group, 2010

73. Interview with Timber and Forestlands Group

74. Interview with Recreation and Public Lands Group, 2010.

75. Powell, S., Cohen, W., Yang, Z., Pierce, J., and M. Alberti. 2008. Quantification of impervious surface in the Snohomish water resources inventory area of Western Washington from 1972- 2006. Remote Sensing of Environment. 112(4): 1895-1908. Study characterizes a 255% increase in urban lands concurrent with a 79% increase in population (for Snohomish and King Counties). Further, over 70% of that land is classified as 'low impervious' indicative of lower density of development.

76. UERL, 2007 Land Cover Classification of high and medium urban (greater than 60% impervious surface per 30m grid cell) cover.

77. Street Network GIS data. Assessed for all road segments within Basin boundary.

78. PSRC, 2012 Puget Sound Economic and Demographic Forecasting: 2006 Puget Sound Economic and Demographic Forecast. Summary of 2000 households outside urban growth boundary.

79. PSRC, 2012. Puget Sound Trends: 2010 Residential Building Permit Trends. http://www.psrc.org/assets/784/trend-d4.pdf

80. The Free Dictionary. Definition of Investment. Last Accessed 04.20.12.

81. Wikipedia. Definition of Investment. Last Accessed 04.20.12.

82. Us White House, Office of Management and Budget. Project America. Transportation: Infrastructure. Last accessed: 04.20.12. http://www.project.org/info.php?recordID=412

83. Puget Sound Energy Integrated Resource Plan. 2011. http://pse.com/aboutpse/EnergySupply/Pages/Resource-Planning.aspx;

84. Interview with Transportation Group, 2010

85. Interview with Risk Management Group, 2010.

86. US Agriculture Census. 2002. Total sales by farm.

87. US Agriculture Census. 2002. per County total number of farms. 2002.

88. Agricultural Census, total acres per County, 2007.

89. Snohomish County, 2009. A community Vision for Sustainable Agriculture in Snohomish County: A study commissioned by the Snohomish Agriculture Economic Development Team for the Snohomish County Agricultural Sustainability Project. Prepared by Nyhus Communications, LLC, Maker Architecture and Urban Deisng and Community Attributes. http://www.co.snohomish.wa.us/documents/County_Services/FocusOnFarming/SecA.pdf

90. The Free Dictionary. Definition of Forestry. Last Accessed 04.20.12.

91. LCCM, 2010. Land Cover Classification for Coniferous, Mixed, Regenerating and Clearcut forest.

92. Timberlands GIS data layer, USGS, 2010.

93. LCCM, 2010. Based on coniferous and mixed forest cover for 1986 and 2007. During this time period the area of 'regenerating' forest cover grew by 400%.

94. Hutyra, L.R., Yoon, B., Alberti, M. Terrestrial carbon stocks across a gradient of urbanization: A study of the Seattle, WA region. Global Change Biology, 17: 783-797, 2011.

95. Major Public Lands, Washington Department of Natural Resources.