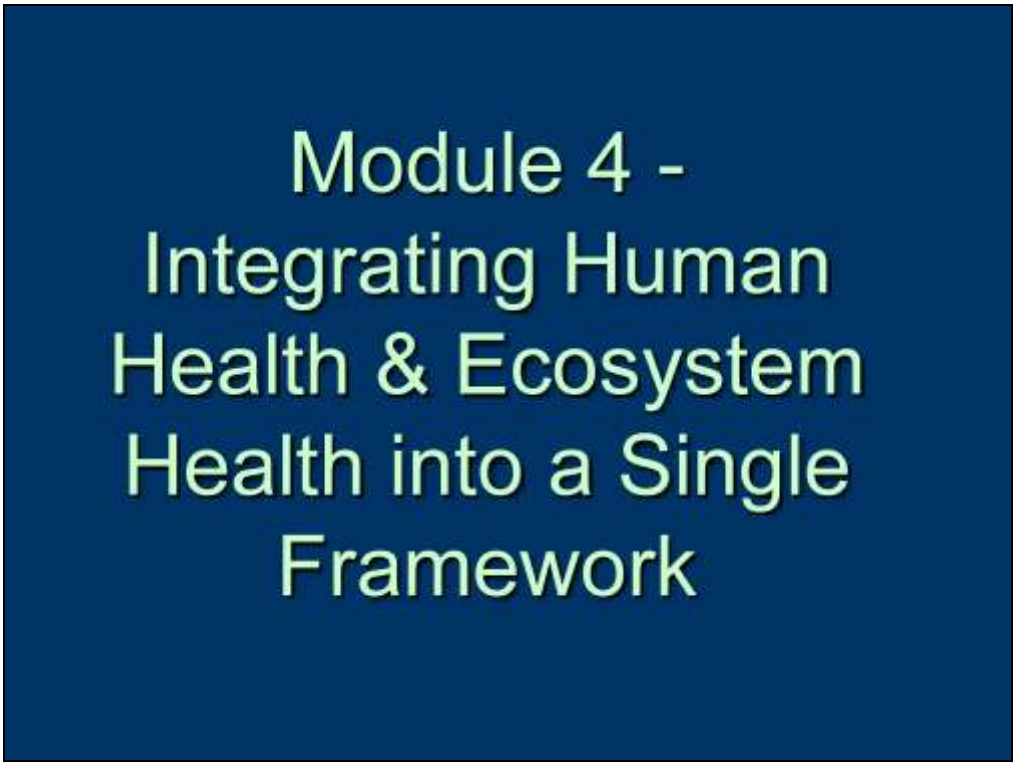
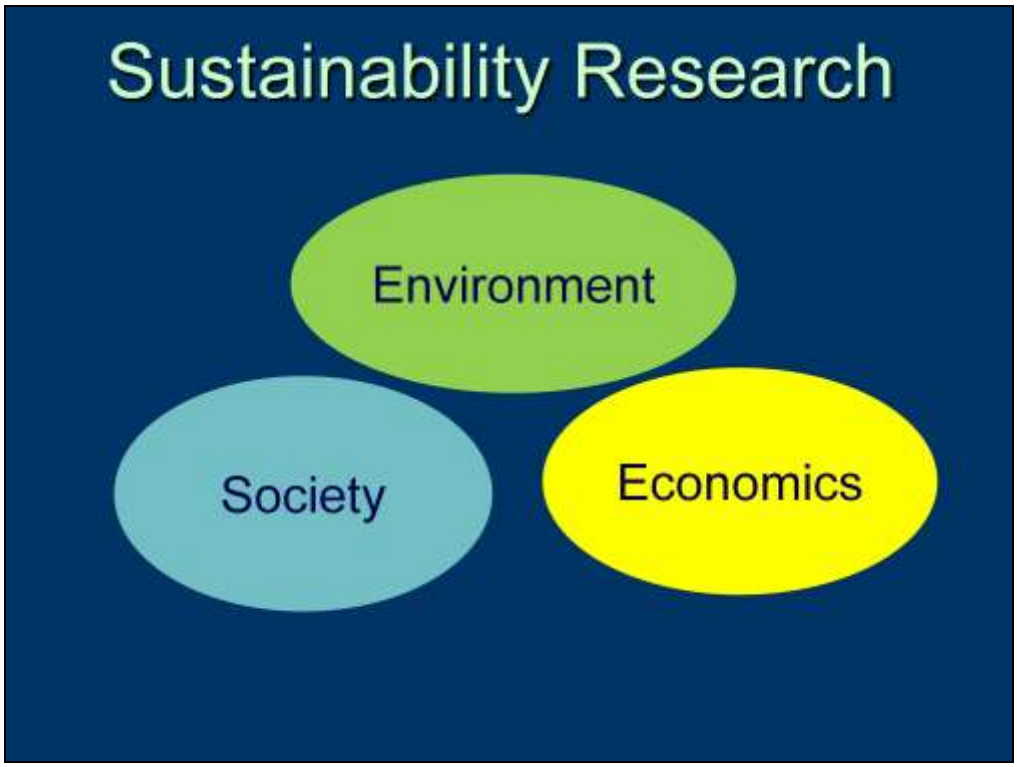


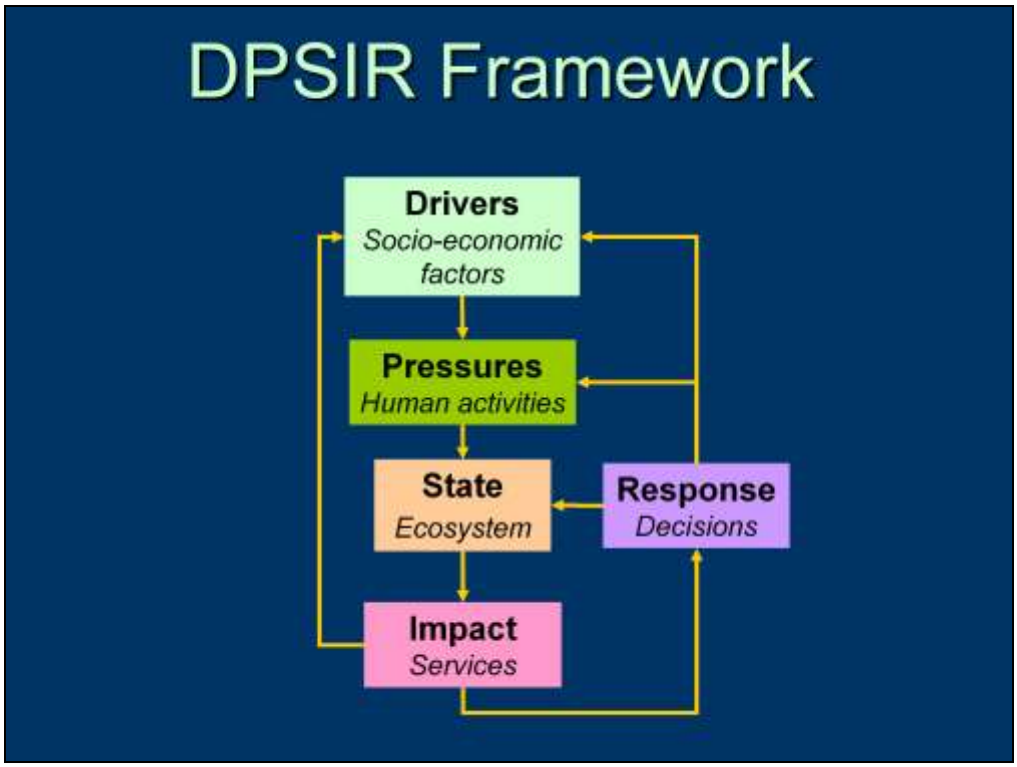

**Module 4: Integrating Human Health & Ecosystem Health into a Single Framework**

This module will present an example of using the DPSIR framework to integrate human health research and ecological research.




**Sustainability Research**

The sustainable well-being of communities is inextricably linked to both the health of the earth's ecosystems and the health of humans living in the community. However, both ecosystem health and human health can be overlooked by individuals, businesses, or regulatory agencies when making economic and social decisions, often due to an inability to foresee the full range of intended and unintended consequences. Yet the full range and long-term impacts of decisions must be understood---environmental health and human health determine the available quantity and quality of natural, human, and social capital necessary for sustainable communities.

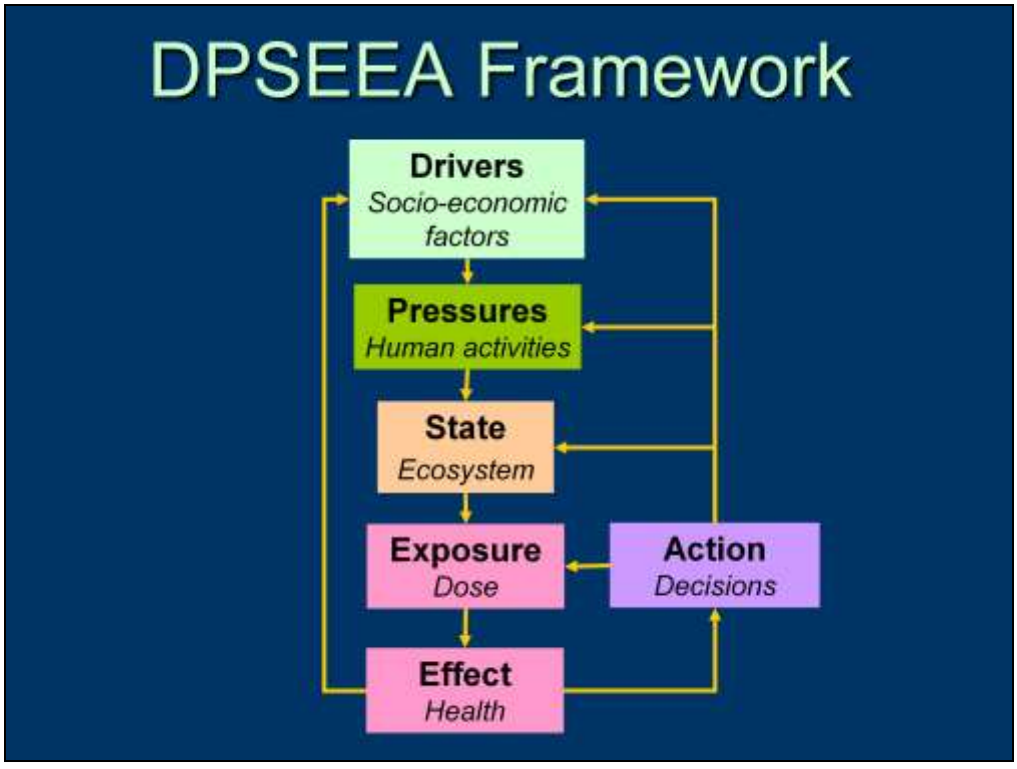



**DPSIR Framework**

Conceptual frameworks provide one tool for capturing, visualizing, and organizing the connections between key factors in a complex system. In Module 2 and Module 3 we presented an overview of the **Driver-Pressure-State-Impact-Response (DPSIR) Framework** as a tool for systems thinking.

- In the DPSIR conceptual framework, **Drivers** are the social, demographic and economic developments in societies and the corresponding changes in life styles, overall levels of consumption and production patterns.
- Drivers function through human activities which may intentionally or unintentionally exert **Pressures** on the environment.
- The pressures exerted by society may lead to unintentional or intentional changes in the **State** of the ecosystem.
- Changes in the quality and functioning of the ecosystem have an **Impact** on the welfare or well-being of humans through the provision of ecosystem services.
- Humans make decisions in **Response** to the impacts on ecosystem services or their perceived value.

Although the DPSIR framework links environmental degradation to human health (Impact category), it lacks many of the social, economic, and behavioral factors that contribute to human health risks.

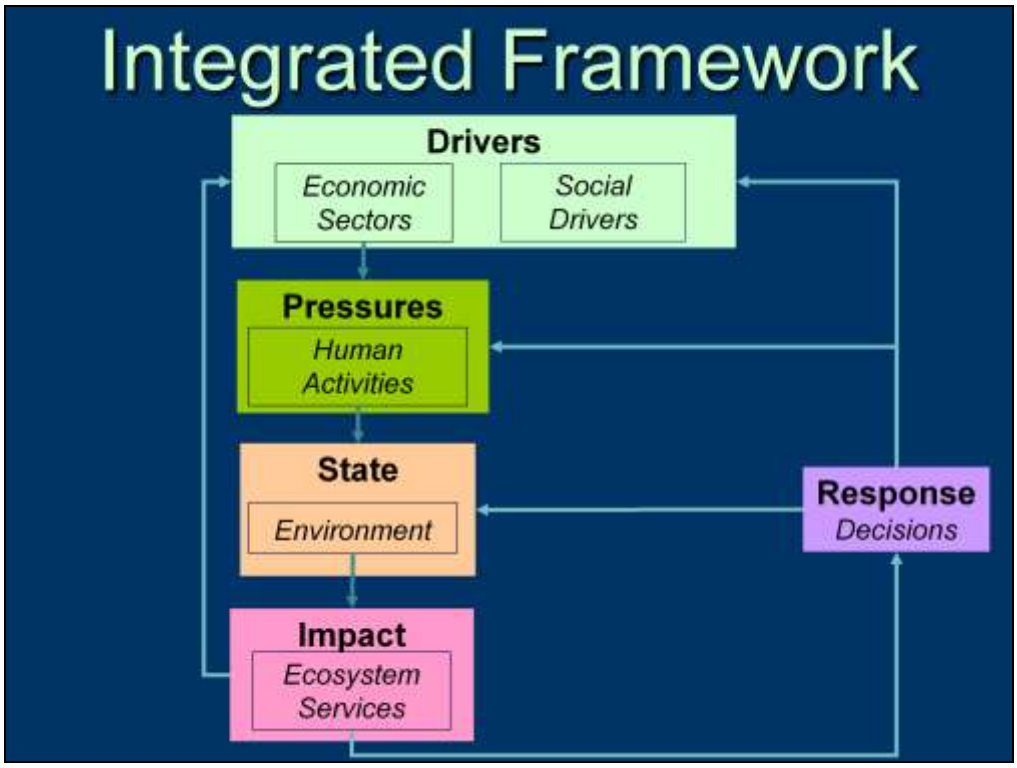



**DPSEEA Framework**

An alternative to the DPSIR Framework is the **Driving force-Pressure-State-Exposure-Effect-Action (DPSEEA)** framework. DPSEEA has been widely used in European and international health assessments (Corvalán et al., 1999).

- In the DPSEEA conceptual framework, **Drivers** are the social, demographic and economic developments in societies and the corresponding changes in life styles, overall levels of consumption and production patterns.
- Drivers function through human activities which may intentionally or unintentionally exert **Pressures** on the environment.
- The pressures exerted by society may lead to unintentional or intentional changes in the **State** of the environment.
- Factors such as human behavioral and lifestyle choice will influence individual **Exposure** to environmental challenges.
- Humans take **Action** by making decisions to reduce the **Effects** on human health.

However, by emphasizing the link between environmental degradation and human health, DPSEEA de-emphasized elements of the DPSIR framework, such as natural capital provided by ecosystems (Impact) that is a core concept of sustainability.




**Integrated Framework: Drivers**

Human health concepts can be incorporated into the DPSIR Framework to provide a single integrated framework.

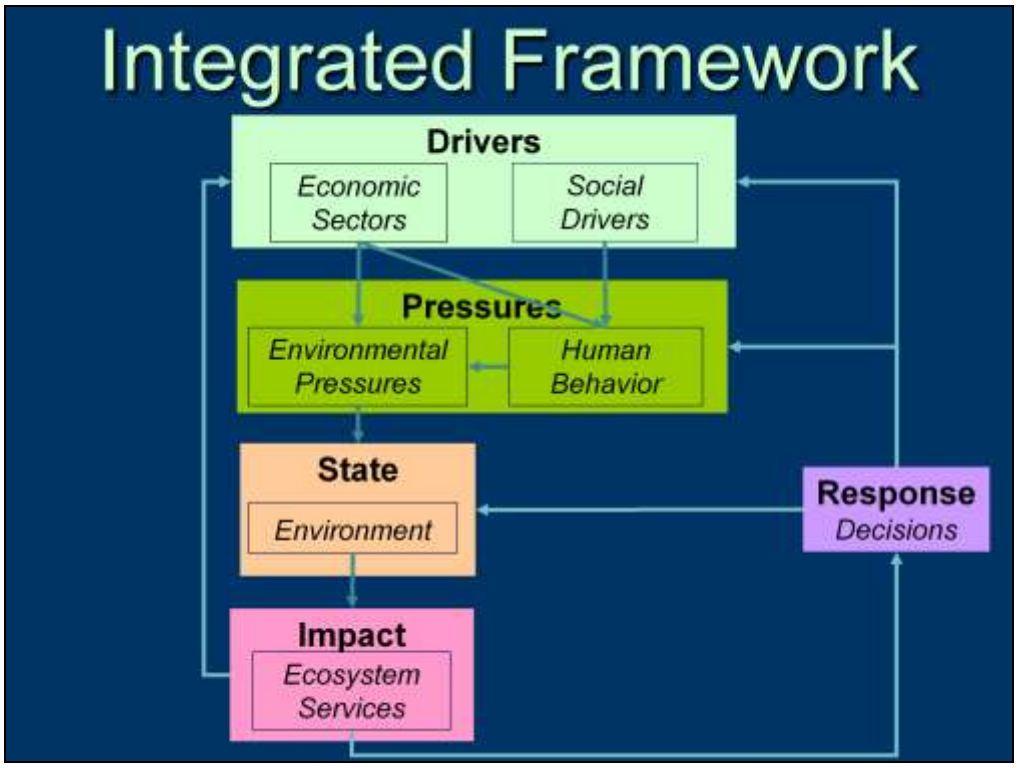
Although DPSIR typically has an environmental focus, a parallel pathway can be added to more explicitly consider human health. In this parallel pathway, social **Drivers** are included in addition to economic sectors.

**Economic Sectors:** Industries that fulfill human needs, or build and maintain the infrastructure needed for the economy to operate. Sectors are be derived from the North American Industrial Classification System (NAICS).

- ***Food & Raw Materials* -** sectors providing food, fuel, and other raw materials, and include Agriculture & Aquaculture, Oil & Gas Extraction, Commercial Fisheries, Forestry, and Mining & Quarrying
- ***Water* -** sectors fulfilling human needs for water include Drinking water supply, and Irrigation
- ***Shelter* -** sectors fulfilling human needs for shelter include Housing (home construction, real estate, single family & multi-unit housing) and Textiles & Apparel
- ***Health* -** sectors fulfilling human needs for health include Medical care, Pharmaceuticals & cosmetics, Social assistance, Waste management sectors, and Public health agencies
- ***Culture* -** sectors fulfilling human needs for culture include Tourism & recreation industry, Schools, Telecommunications, Scientific research, and Social organizations
- ***Security* -** sectors fulfilling human needs for security include National defense, Public administration, and Law enforcement
- ***Infrastructure* -** sectors provide the physical, organizational, and technical support for the economy to function and include Manufacturing & trade, Transportation sectors, Construction & civil engineering sectors, Finance & insurance industries, Utilities, and Technical Services

**Social Drivers:** The social characteristics of a society that fulfill human needs for social relations, equity, cultural identity, or governance.

- ***Governance* -** the political disposition or type of government of a community; could include voting patterns or the role of decision-makers
- ***Cultural Identity* –** the history, social, and cultural attitudes that define a community; could include urban or rural communities, tribes, or coastal communities, or ethnic or religious identity
- ***Social Relations* –** the day-to-day interactions in a community, often reflecting the cultural identity; may include religious affiliations, social groups, marriage, or family dynamics
- ***Equity* -** fairness of opportunities in a community; may include access to education, health care, or jobs




**Integrated Framework: Pressures**

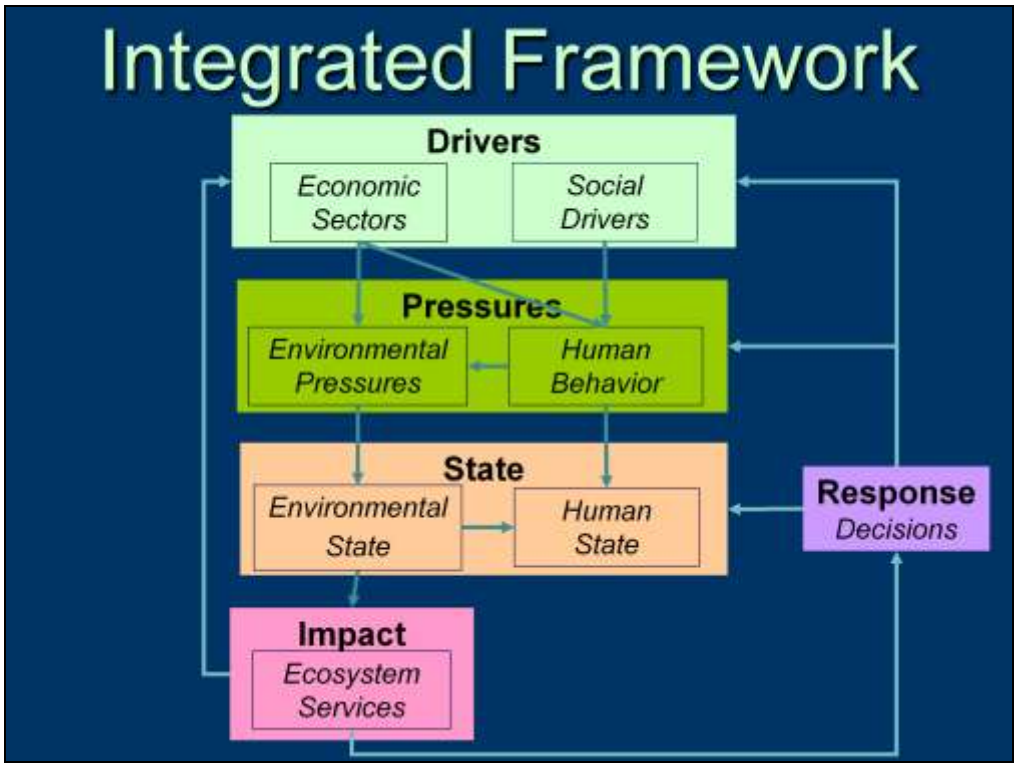
In addition to creating **Pressures** on the state of the natural environment, economic sectors and social factors, such as governance or culture, can influence human behavior. Human behaviors (e.g. purchasing habits, commuting, recycling) can also influence the degree of environmental pressures created through the activities of economic sectors.

**Environmental Pressures** – Activities that alter the condition of the environment

- ***Landuse changes*** - alterations of the natural landscape, typically associated with population growth, including Coastal development, Land development, Shoreline alteration, Hydrologic modifications, Deforestation and devegetation. Many landuse changes result in the creation of impervious surfaces.
- ***Discharges*** – direct inputs of pollutants from the operation of industries or vehicles, or the diffuse distribution of contaminants from agricultural lands, roads, or lawns through ground-water or storm-water run-off; and includes Applied chemicals such as fertilizers, pesticides, cleaners, or solvents, Atmospheric emissions including greenhouse gases, Waterborne discharges from point or non-point sources, and Solid waste disposal or littering.
- ***Contact uses*** are human activities that lead to a direct alteration or manipulation of the environment, and include Physical damage from dredging, filling, or trampling, Biological additions such as ballast discharges, release of non-natives, or creation of artificial habitat, Biological harvest such as harvesting or fishing

**Human Behavior** – individual human actions that contribute to personal vulnerability, risk of exposure, or influence the intensity of environmental pressures

- Mobility – includes walking, climbing, or utilization or any mode of assisted transportation (e.g., automobiles, planes)
- Self care – includes personal hygiene, housekeeping, or cooking habits
- Lifestyle choices – includes transportation choice, consumptive patterns, resource use & recycling, smoking, eating habits, or choice of housing




**Integrated Framework: State**

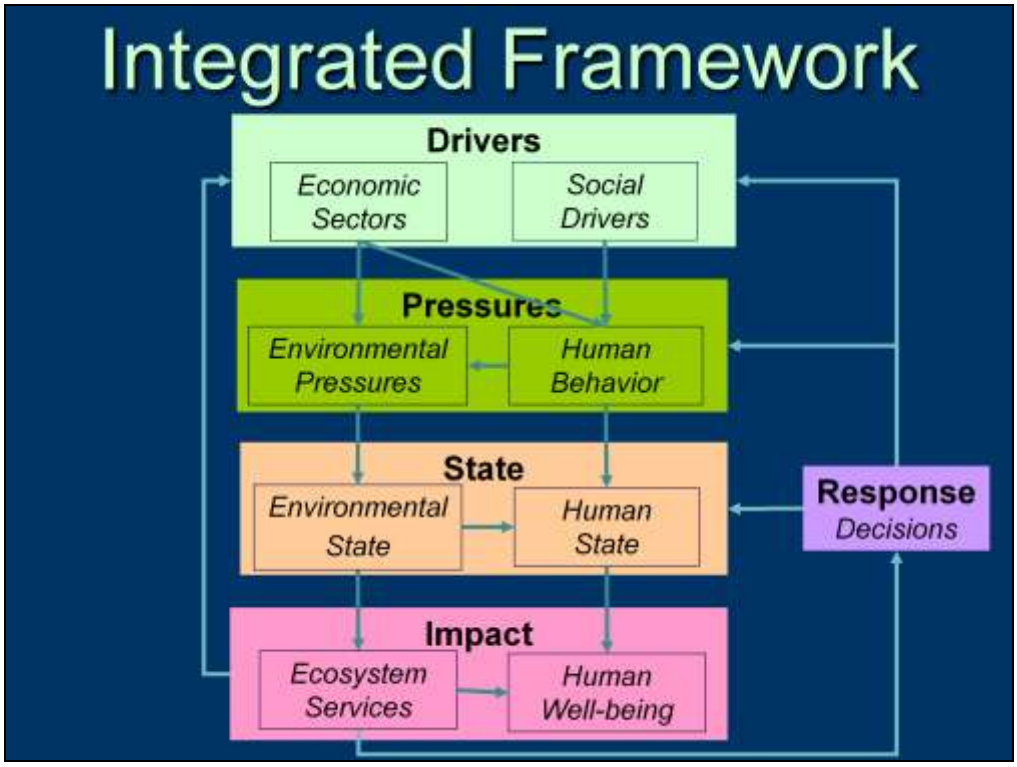
Human activities create Pressures on the **State** of abiotic (physical & chemical) and biological (humans and other biota) components of the ecosystem. The condition of the built and natural environment, as well as human behaviors, can influence human exposure and effects on human health.

**Environmental State** – the condition of the physical, chemical, and biotic environment in which humans live, depend, or may be affected by

- ***Abiotic state*** - the magnitude, frequency, and concentration of abiotic components of the environment. The abiotic environment influences the survival, growth, and distribution of living organisms in the Biological state.
- ***Physical & chemical environment*** - includes Physical variables such as climate, air and sea temperature, precipitation, storms & hurricanes, drought, hydrology, ocean circulation patterns, or fire, and Chemical variables such as nutrients, pH, atmospheric $CO_2$ levels, salinity, or contaminants in air, water, soil, or food.
- ***Built environment*** – man-made physical structures or extreme modifications of the natural environment, including buildings, roadways, household furnishings, landfills, brownfields, or parks, and their pattern of distribution or density within the human habitat.
- ***Biota -*** the biological components of the ecosystem and their interactions. In general, this includes plants or animals that provide the living habitat and base of the food web that supports higher trophic levels. Biological condition may be measured by individual- or community-level attributes.
- ***Living habitat*** - sessile plants and animals that compete for space, light, and nutrients within the physical habitat, and generally form the basis of the food web as primary producers. Examples include deserts, wetlands, grasslands, forests, coral reefs, and agricultural lands.
- ***Inhabitants*** – the biota, typically animals, associated with and dependent on living habitat for resources & shelter including birds, mammals, fish, reptiles, amphibians, and invertebrates.
- ***Invasive species*** compete with, prey upon, or alter interactions among native species. They may enter the system through intentional introductions, hitchhiking on human transportation (cars, boats) or other animals, or accidental release of pets, garden plants, or aquarium species. Invasive species terrestrial animals and plants, or aquatic species.
- ***Microorganisms and pathogens*** may have benefits in ecosystem function, such as decomposers or mycorrhizae, or be disease-causing agents, and include bacteria, fungi, and viruses.

**Human State –** the condition of individuals or community-level attributes of the human population

- ***Individuals*** – measurable attributes of individuals that reflect impacts of environmental degradation or personal behavior
- ***Personal characteristics***– aspects of the individual person that contribute to vulnerability including age, gender, or ethnicity
- ***Body Systems*** – the condition (healthy or diseased) of key human body systems, derived from the MERCK Manual, including respiratory, immune, gastrointestinal, reproductive, endocrine, and neurological systems, mental health, and genetics
- ***Communities*** – the characteristics of the community in which humans live, including the population size or density, ethnic diversity, socio-economic status




**Integrated Framework: Impact**

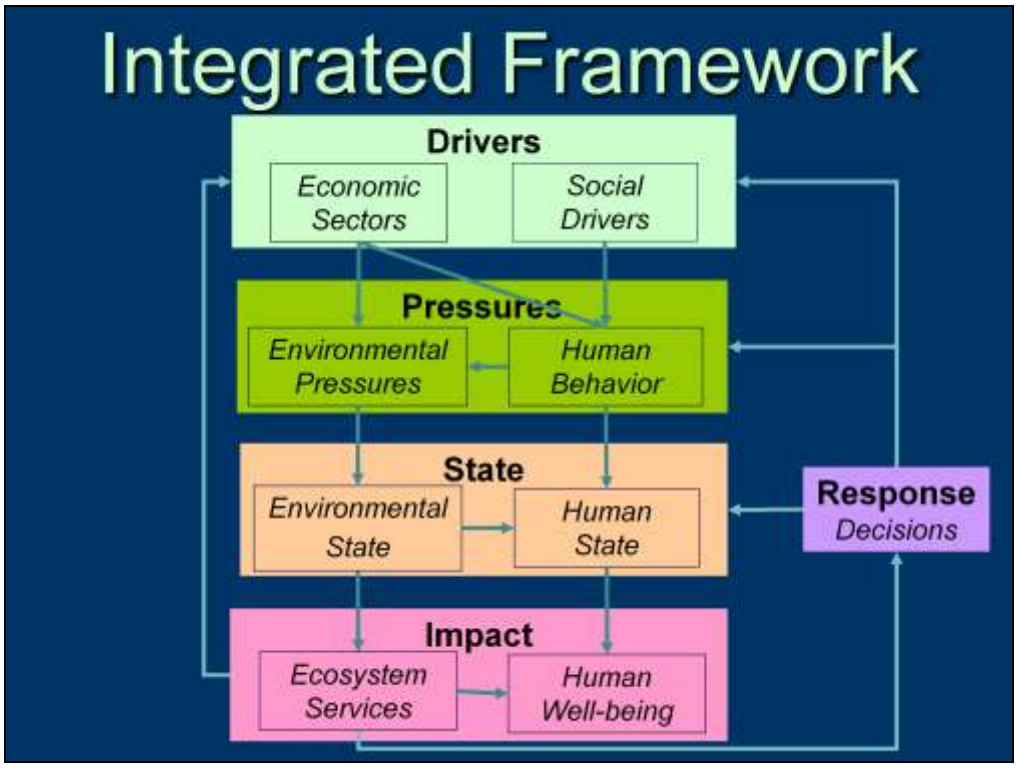
Changes in the quality and functioning of the ecosystem or human condition have an **Impact** on the welfare (well-being) of humans. Ecosystem services, in particular, are the benefits that ecosystems can provide. Other factors, such as human health, habitat, & behavior also contribute to human well-being.

**Ecosystem Services**: Functions and products of the ecosystem that benefit humans in the short term or long term. Services depend on the attributes of the ecosystem. The Millennium Ecosystem Assessment (*Hassan et al. 2005*) defined four categories of ecosystem services:

- ***Supporting services*** - biophysical processes that maintain the functioning of the ecosystem, and are necessary for the production of other ecosystem services, but may not have direct impacts to humans, including soil stabilization, wave energy attenuation, nutrient & contaminant processing, water cycling, carbon storage & cycling, and provision of resources and habitat to critical species.
- ***Regulating services*** – biophysical processes that regulate the ecosystem, including air quality regulation, climate regulation, water regulation, erosion regulation, water purification, waste treatment, disease & pest regulation, pollination, or natural hazard regulation.
- ***Provisioning services*** – the biological, chemical, or products obtained or harvested from ecosystems for human use including water resources, food resources, biochemical or genetic resources, fuel, fiber, or ornamental resources.
- ***Cultural services*** – include the nonmaterial benefits people obtain from the ecological integrity of ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, including recreational value & ecotourism, aesthetic value, cultural value, spiritual or religious value, sense of place, educational or knowledge value, research potential, or untapped future potential.

**Human Well-Being –** a quantification of the degree of fulfillment of basic human needs for food, water, health, security, culture, and shelter. The State of Human condition (e.g. physical and psycho-social growth and development, presence of diseases) and the provisioning of ecosystem services are major contributors to human well-being. Socio-economic drivers depend upon the availability of natural capital (ecosystem services) and function to maintain or improve human well-being.

- ***Health & safety*** – life span, medical or insurance costs, sick days, pain & suffering
- ***Economic prosperity*** – productivity, ability to work, ability to afford needed things (income)
- ***Cultural and Social Well-Being*** – “happiness”, love, sense of belonging

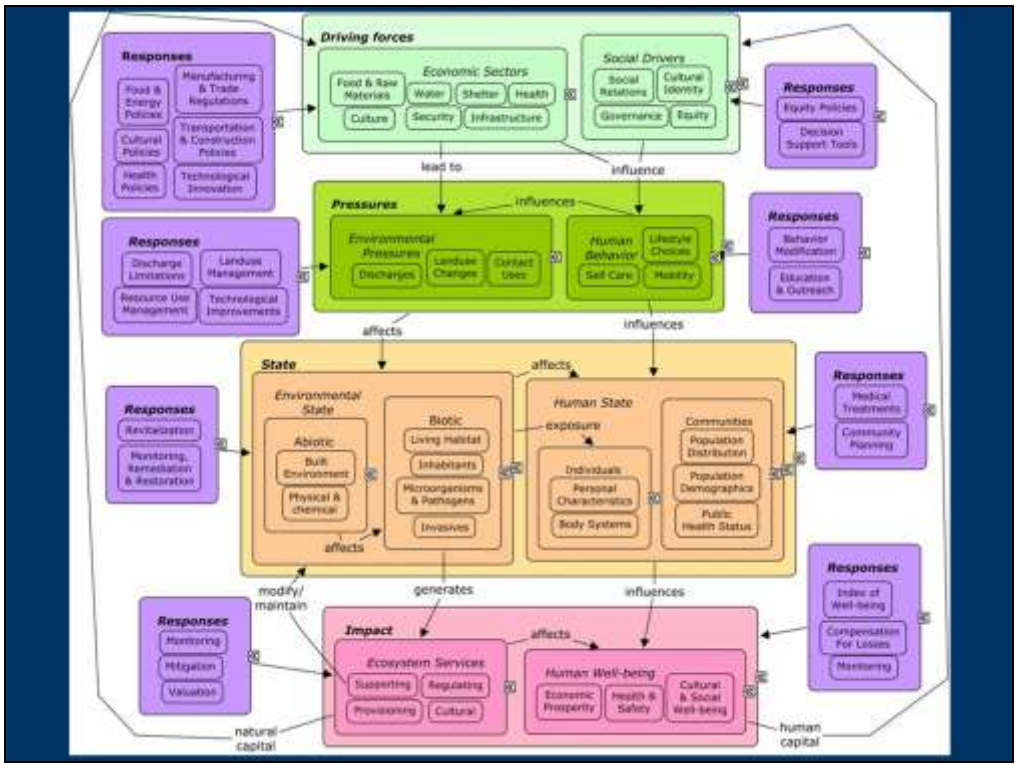



**Integrated Framework: Response**

**Responses** are actions taken by groups or individuals in society and government to prevent, compensate, ameliorate or adapt to changes in well-being due to the state of the environment or condition of human health.

Decisions that benefit one economic sector may lead to environmental degradation that weakens another economic sector. For example, Impacts on ecosystems services and human well-being will affect the quality and quantity of natural capital and human capital available to economic sectors. By linking Impacts back to socio-economic Drivers (left, upward arrow), tradeoffs in the system can be identified.

- ***Driver-level Responses*** – attempt to modify economic sectors by increasing the number of available options or alternatives to fulfill a given need, and may includes energy policies, health policies, transportation policies, construction policies, tourism & recreation policies, educational reforms, or technological innovations. Also includes responses to modify social drivers, such as through environmental justice policies or decision support.
- ***Pressure-level Responses*** – attempt to control the ongoing activities of socio-economic drivers that place pressure on the environment; Includes Land-use management through permitting, city planning, or zoning, Discharge limitations through regulations or technological improvements, and Resource-use Management through harvesting regulations or protected areas, or agricultural best management practices; may also attempt to modify human behavior through outreach and education.
- ***State-level Responses*** – directly attempt to restore, modify, or maintain the condition of the environment through Monitoring, remediation, & restoration or setting water quality or air quality standards. Responses may also attempt to modify the built environment through technological improvements, such as removal of hazardous factors. Responses may also attempt to directly modify human condition through medical treatments or community planning to identify or ameliorate disparities.
- ***Impact-level Responses*** – attempt to quantify or modify ecosystem services through valuation, monitoring, subsidies, or mitigation, and to quantify human well-being through index development or monitoring.




**Integrated DPSIR Concept Map**

Examples can be hierarchically diagrammed within categories to draw an integrated DPSIR conceptual map.

The Integrated DPSIR Glossary and Integrated DPSIR Concept Map are intended to serve as starting points for creating a problem-specific or system-specific DPSIR.

Software programs, such as Microsoft Powerpoint, CMAPTools, or other drawing applications, are useful for creating concept maps or flow-chart diagrams. A specific DPSIR can either be created from scratch, drawing keywords and connections from either the glossary or the concept map. Alternatively, the Integrated DPSIR Concept Map may be downloaded and modified. Concepts can be removed, added, or altered to reflect the specific problem or system. It is anticipated that details of the specific issue of concern will need to be added, such as key species or interactions, human diseases, particular contaminants of concern, etc.

These files are available on the DPSIR Tutorial Homepage.

IntegratedDPSIR.cmap

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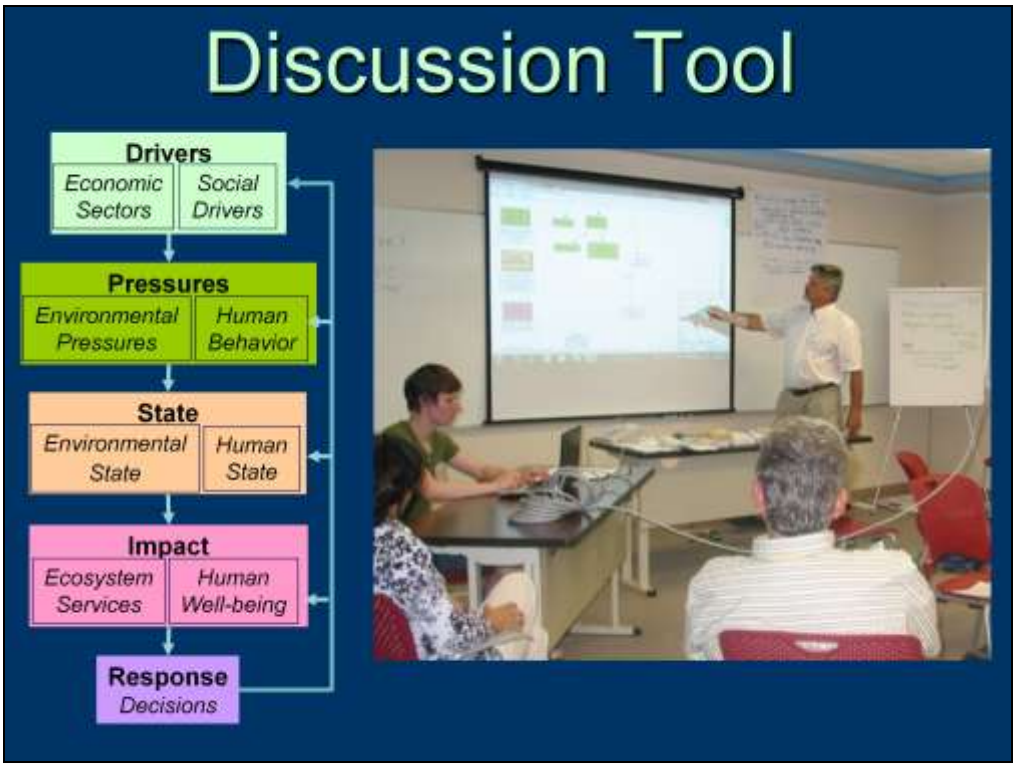
IntegratedDPSIR_Glossary.pdf




**The Integrated Framework as a Discussion Tool**

The process of creating a conceptual model allows decision-makers, stakeholders, or scientists to characterize major stressors, interactions, and tradeoffs related to an issue, or to brainstorm alternative decision options.

The DPSIR Framework provides a scaffold to help guide discussion, and ensure key concepts (e.g. economic drivers, human well-being, decision options) are not overlooked. Questions can be used to guide discussion, stepping through each DPSIR category to elicit information toward building a conceptual model for the given issue under consideration.

**Discussion Questions:**

***Drivers:*** What are the key Economic Sectors involved that may be creating pressures on the environment? What are the key Social Drivers, including political or cultural drivers, which may have influence?

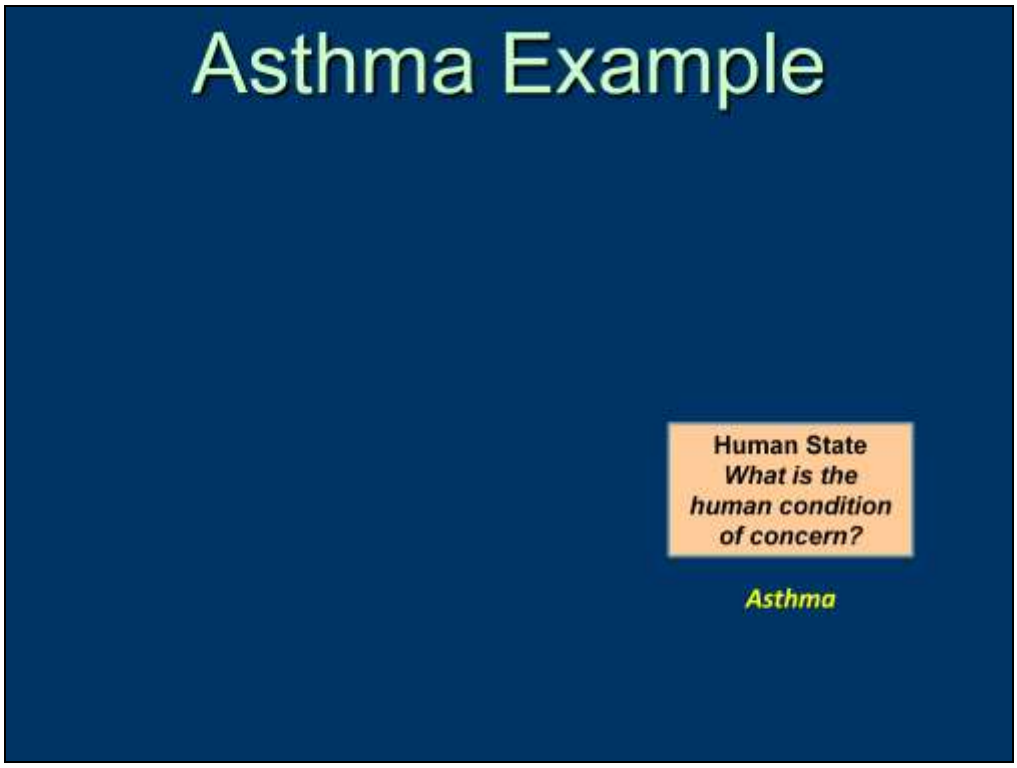
***Pressures:*** What human activities cause Environmental Pressures? What individual Human Behaviors or choices have influence on human condition or quantity of pressures on the environment?

***State:*** How do activities affect the Environmental State, including the condition of the abiotic, biotic, or built environment? How does environmental degradation or human behavior affect Human State or condition, including individual human health or community-level characteristics?

***Impact:*** What do humans gain from the environment in the form of Ecosystem Services? What are the consequences of changes in human condition or change in ecosystem services on Human Well-being, including prosperity, safety, and social well-being?

***Trade-off Drivers:*** What are the costs of loss or benefits of ecosystem services to the economy or society? What are the costs of loss or benefits of human well-being to the economy or society?

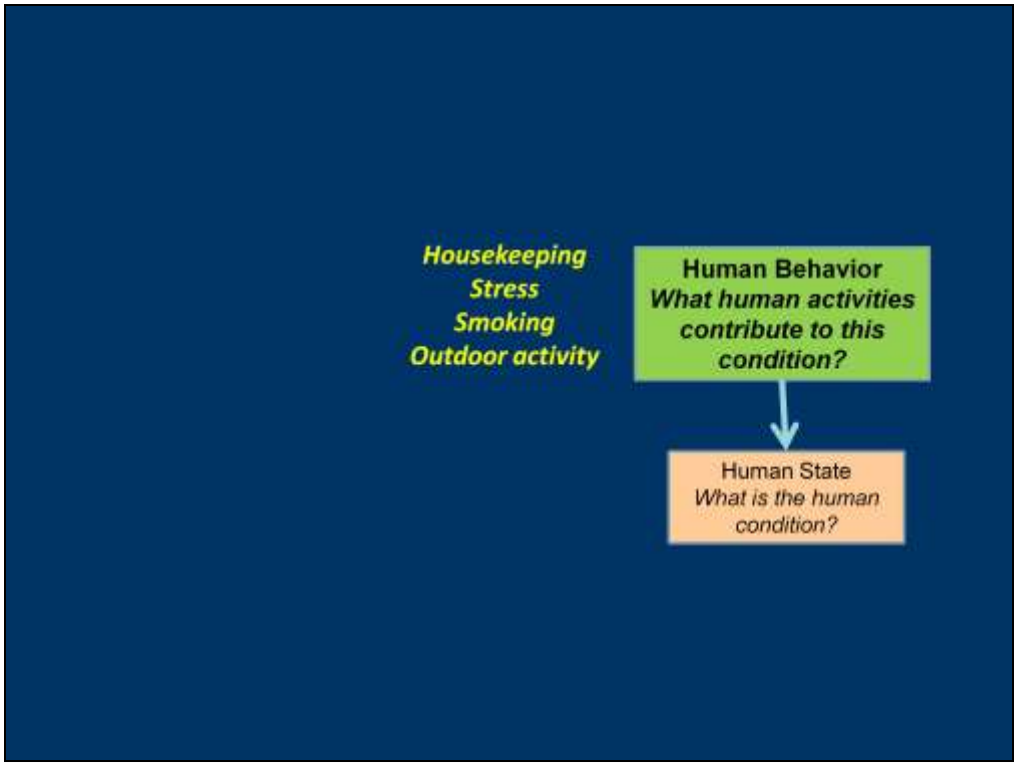
***Response:*** What Responses can be taken to affect drivers, pressures, state, or impact? What actions can be taken to affect drivers, pressures, state, or impact?




**Asthma Example**

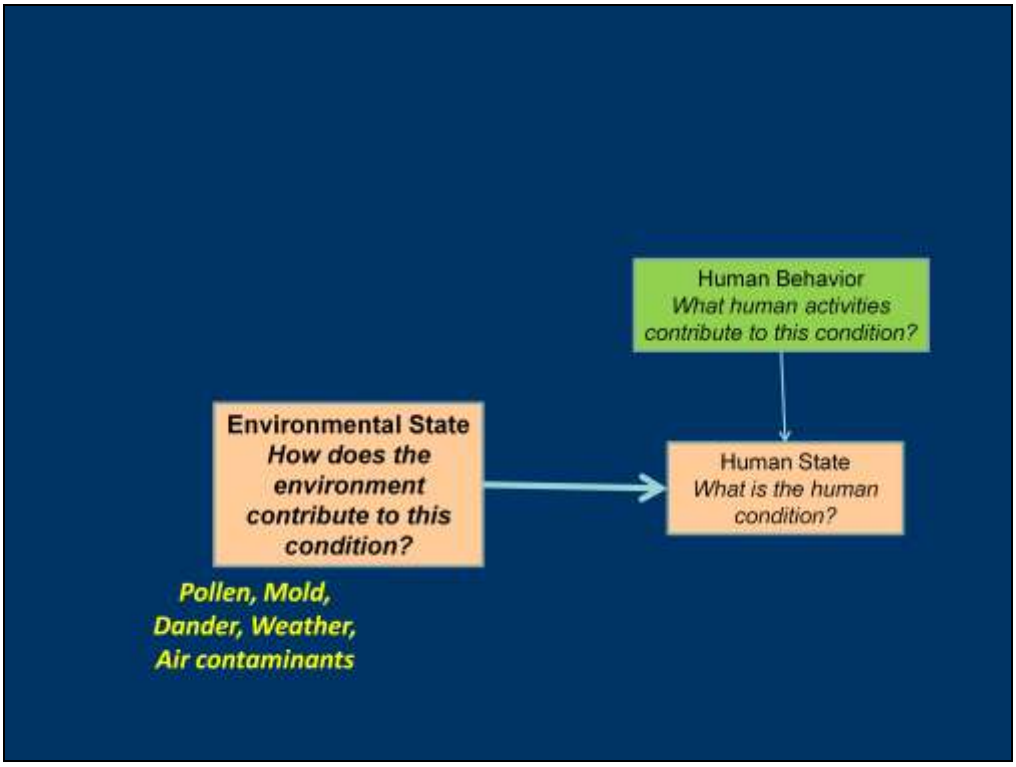
As an example, we present the process of how a conceptual model might be drawn for the issue of asthma. In this example, the thought-process starts with Human State. However, it could start anywhere in the DPSIR. For example, a conceptual model might be built around a given socio-economic driver (transportation concerns), pressure (nutrient loading), or response (waste management options).

To begin discussion, we ask “What is the human condition of concern?”. For this example, it is “Asthma”.



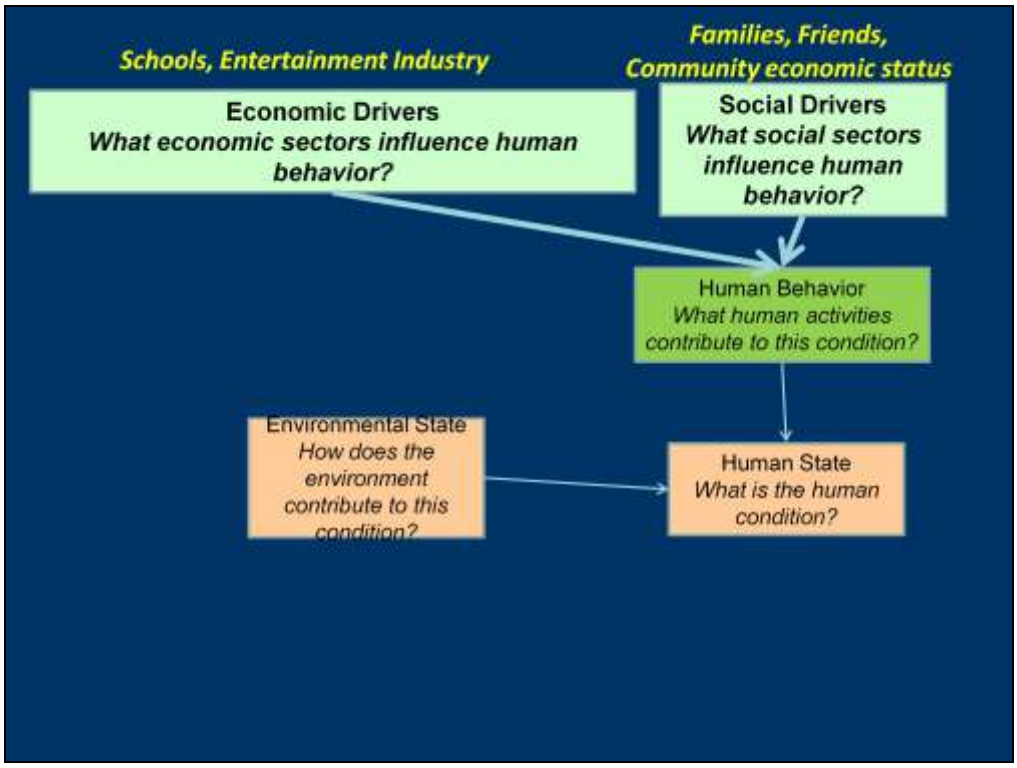

**Asthma Example: Human Behavior**

Next we ask, “What human behaviors might contribute to this condition?” The answers might include housekeeping practices, stress, smoking, and outdoor activities.



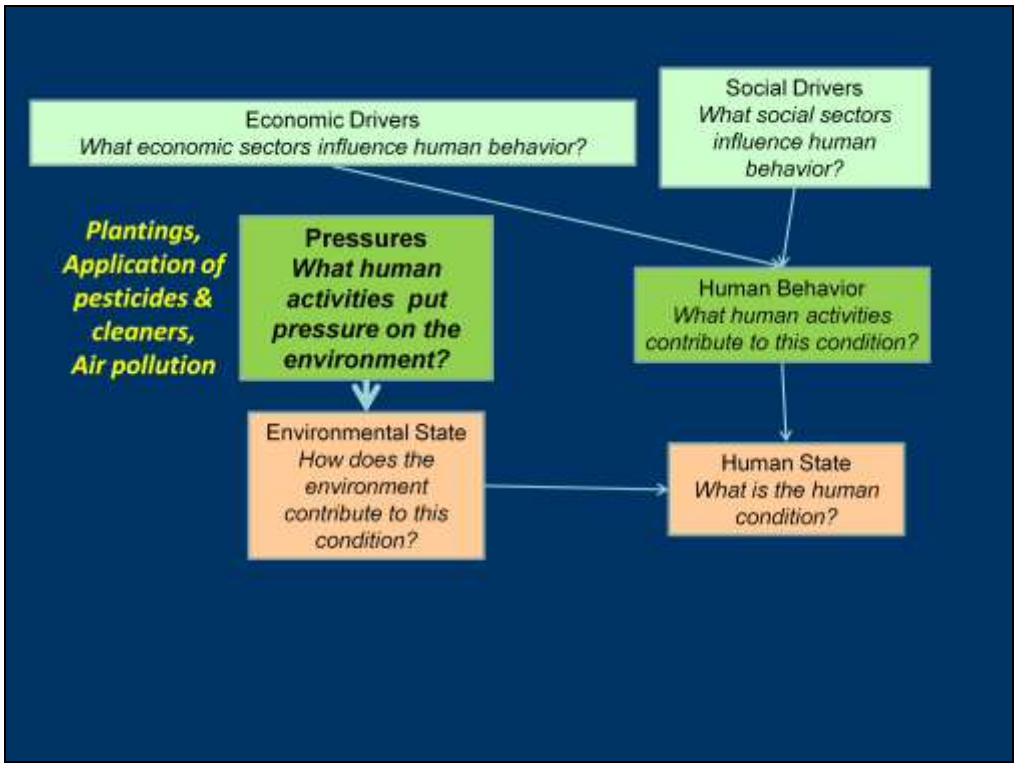

**Asthma Example: State**

Next we ask, “How does the condition of the environment contribute to this health condition?” The answers might include pollen, mold, animal dander, contaminants in the air, or changes in the weather.



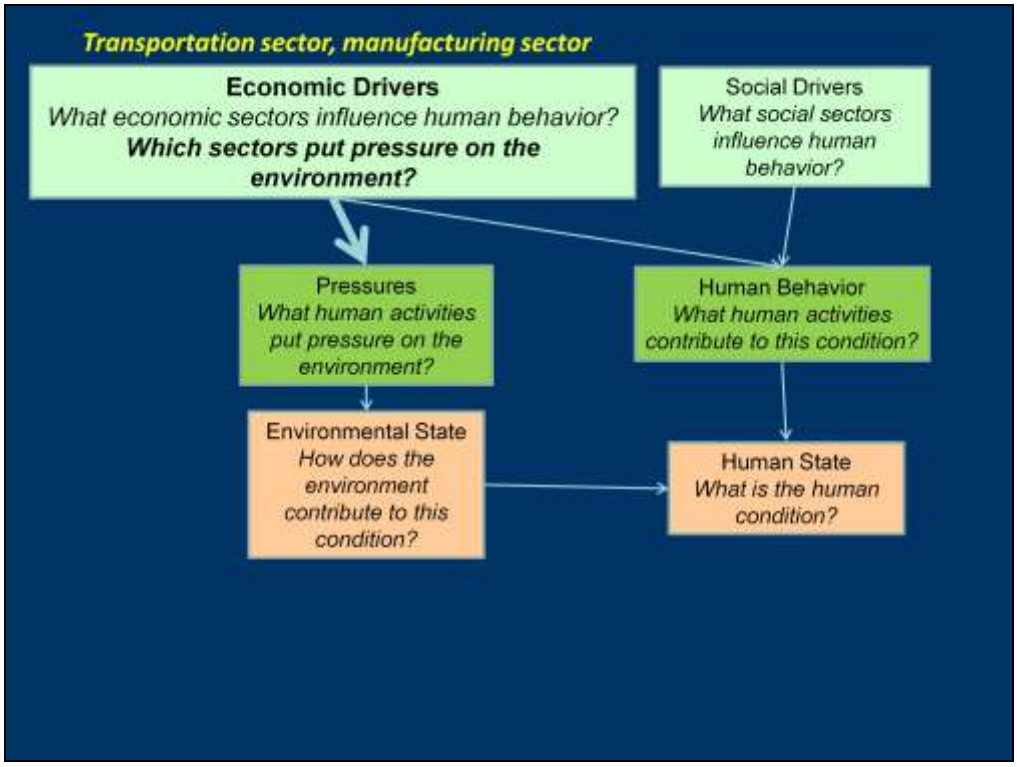

**Asthma Example: Drivers**

Next we ask, “What economic sectors or social factors might influence human behavior?” Economic sectors which might influence human behavior include schools or the entertainment industry. Social factors might include family, friends, or community economic status.



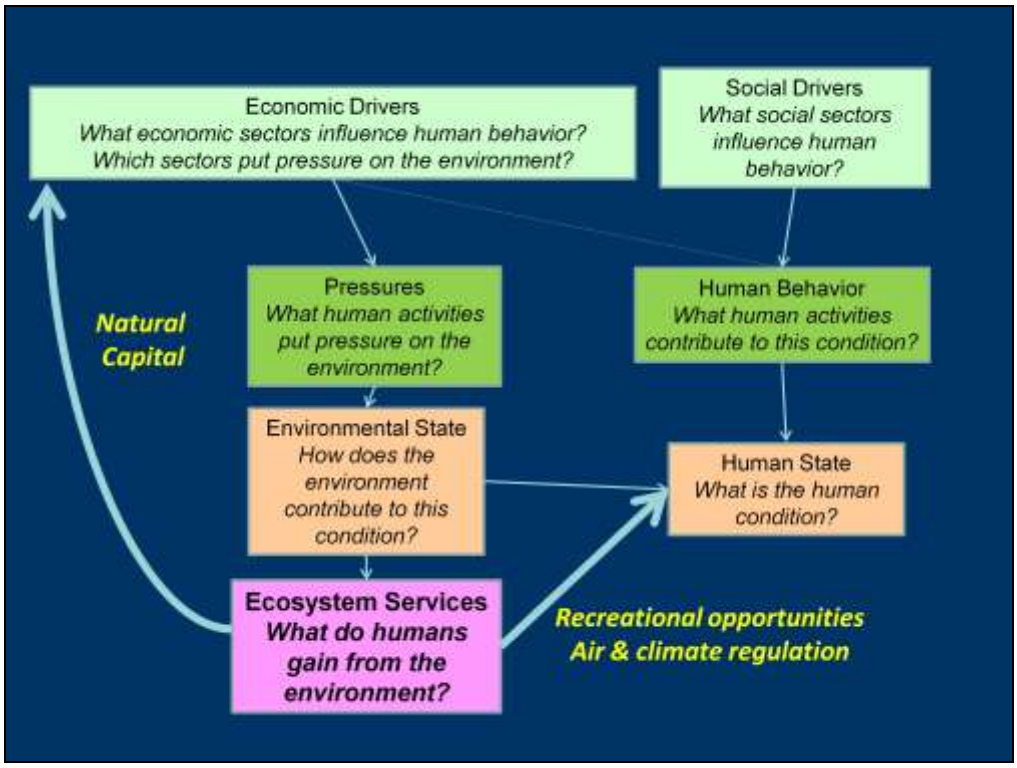

**Asthma Example: Environmental Pressures**

Next we ask, “What human activities might alter the condition of the environment?” Environmental pressures that influence mold, pollen, or contaminants in the environment might include landscaping practices, applications of chemicals such as pesticides or cleaners, and air pollution.



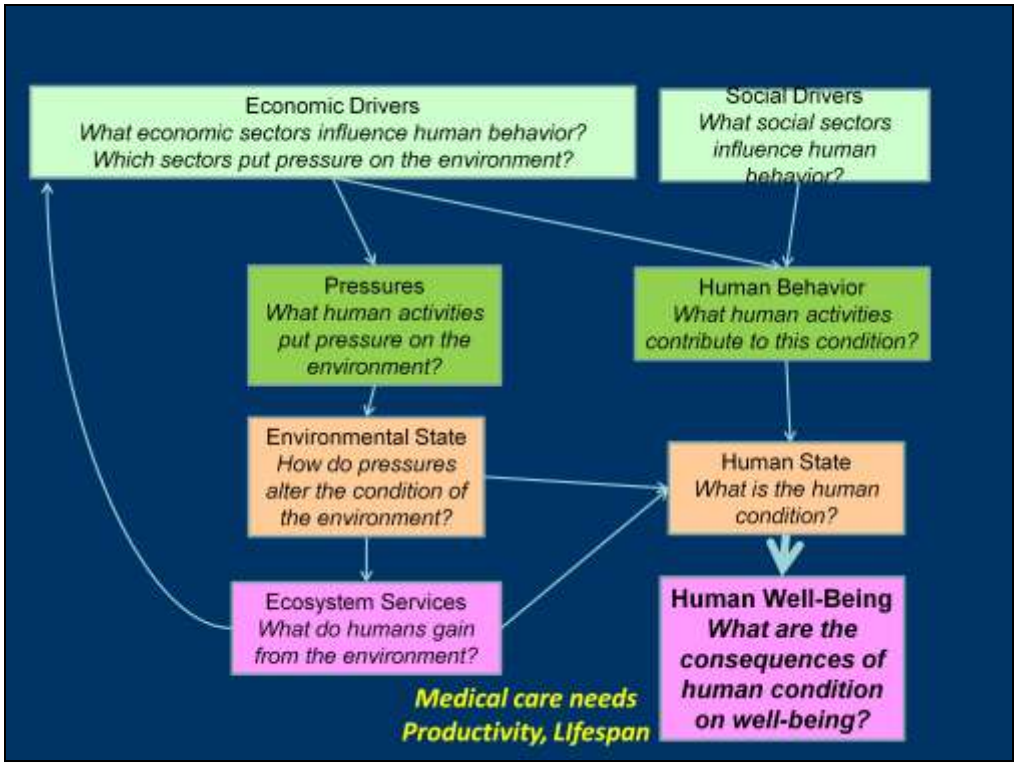

**Asthma Example: Drivers**

Next we ask, “What economic sectors might be contributing to pressures on the environment?” In this case transportation and manufacturing might be contributing to air pollution, local governments or the housing industry might be responsible for urban landscaping and planting choices.



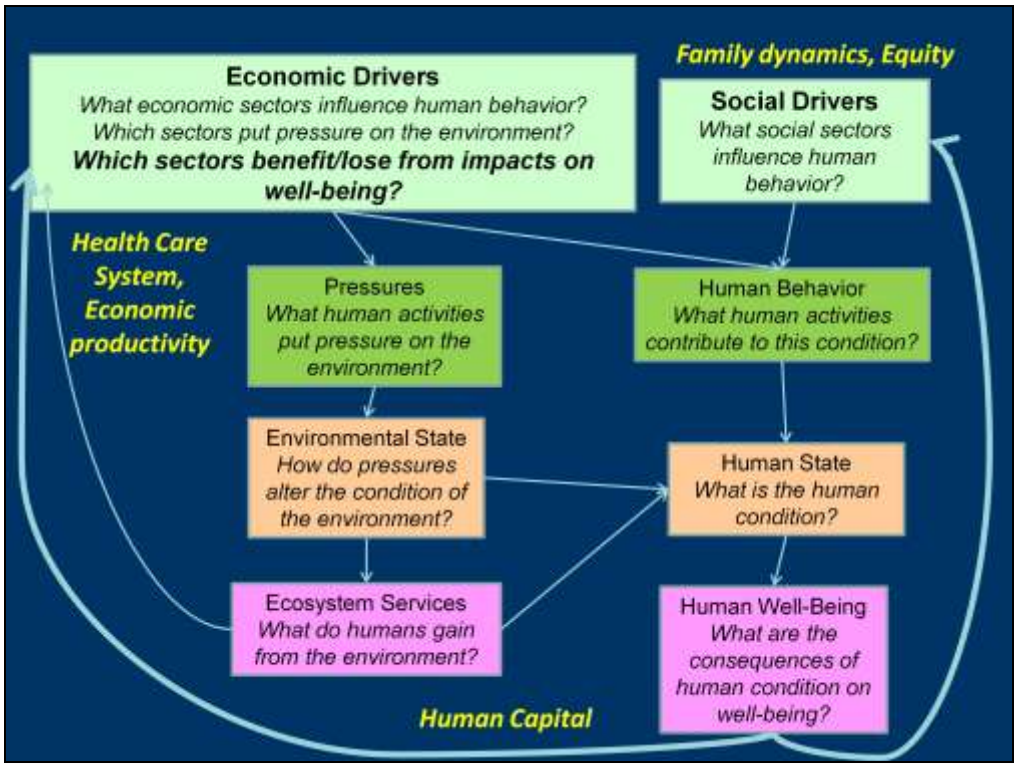

**Asthma Example: Ecosystem Services**

Next we ask, “What are humans gaining from the environment?” In other words, “How might a degraded environment impact human condition?” In this case, the natural environment might be contributing to air & climate regulation and green spaces might provide recreational opportunities to reduce stress or get some fresh air. Ecosystems also provide natural capital for economic sectors, such as food, fuel, and other natural resources. Hence decision options which reduce asthma, such as a reduction in air pollution, may have unintended benefits in improving availability of natural resources.



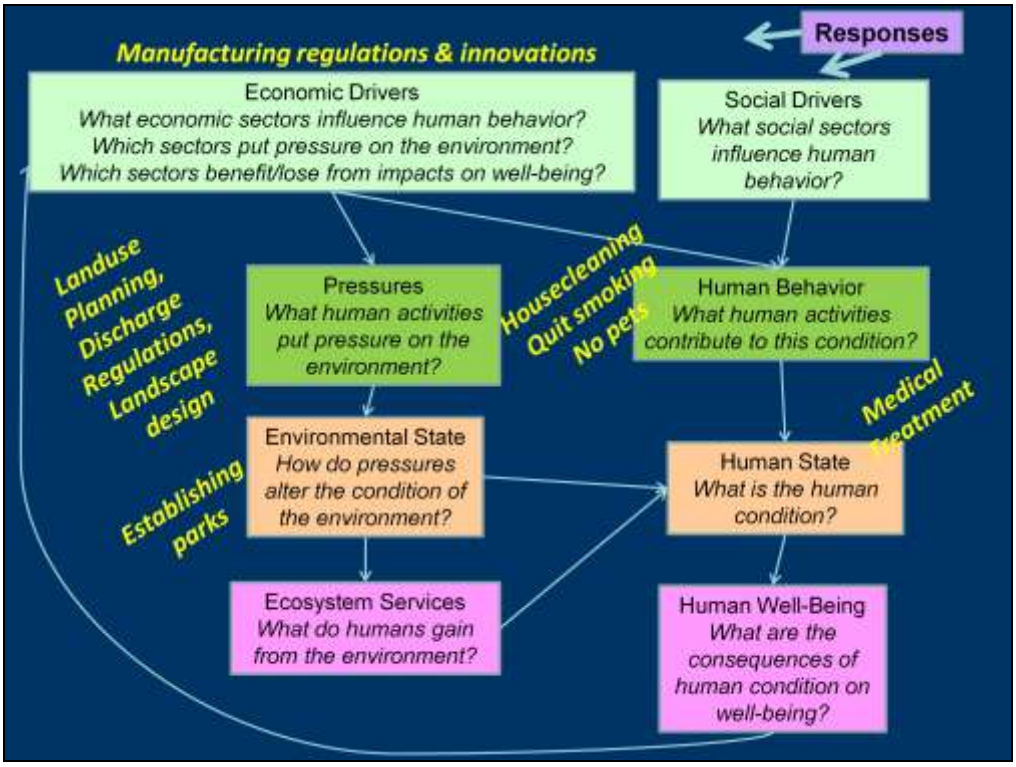

**Asthma Example: Human Well-Being**

Next we ask, “What are the consequences of human condition on human well-being?” In this case, asthma may lead to increased medical care needs, it may reduce ones lifespan, or reduce job productivity if the individual is frequently sick or caring for sick family members.



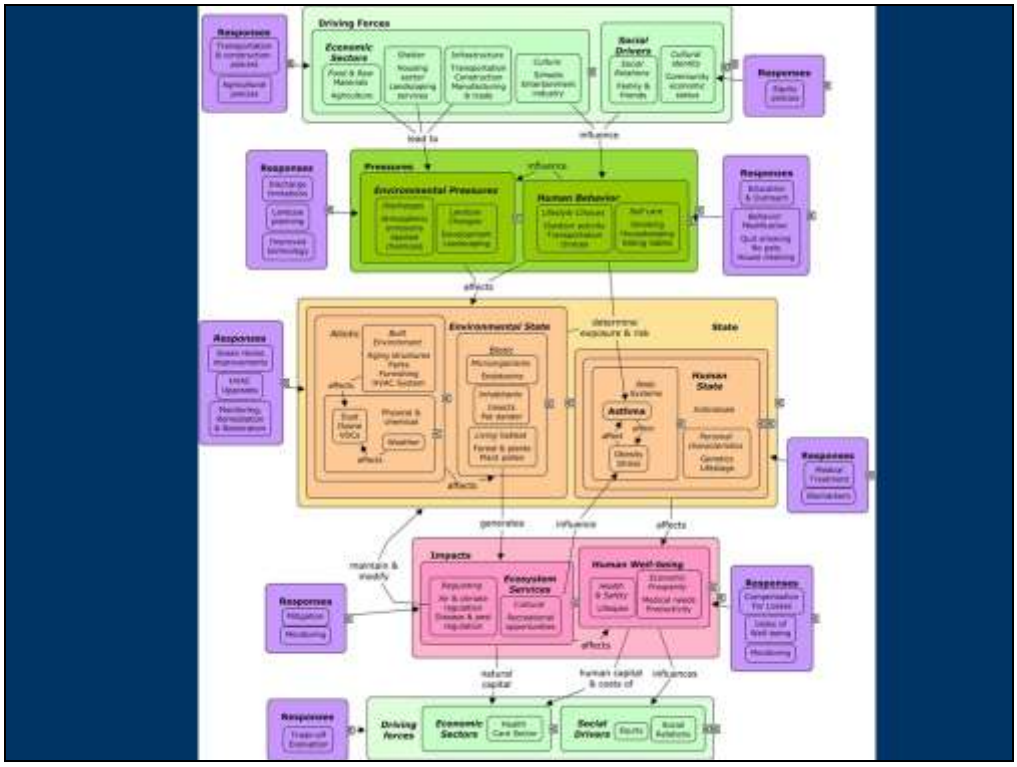

**Asthma Example: Trade-off Drivers**

Next we ask, “What are economic sectors or social drivers might benefit or lose from a change in human well-being?” In this case, controlling asthma is certainly of interest to the health care system, but high rates of asthma, increased medical costs, and decreased worker productivity have potential to have broad economic costs across all sectors. Moreover, individual well-being can influence family dynamics or one’s sense of equity, if certain communities or cultures are more likely to be exposed.




**Asthma Example: Responses**

Finally we ask, “What are decision options are available to address the issue?” By first identifying Drivers, Pressures, State, and Impact, we can identify potential decision options across all levels of the DPSIR. Driver-level responses might include manufacturing regulations or innovations to improve housekeeping or reduce allergens. Pressure-level responses might include landuse planning, implementing air emissions regulations, implementing landscape design practices that reduce pollen. Options to modify human behavior might include improving housecleaning practices, quitting smoking, removing pets from the household. State-level responses might include establishing parks to enhance green spaces, or improving human health directly through medical treatment.

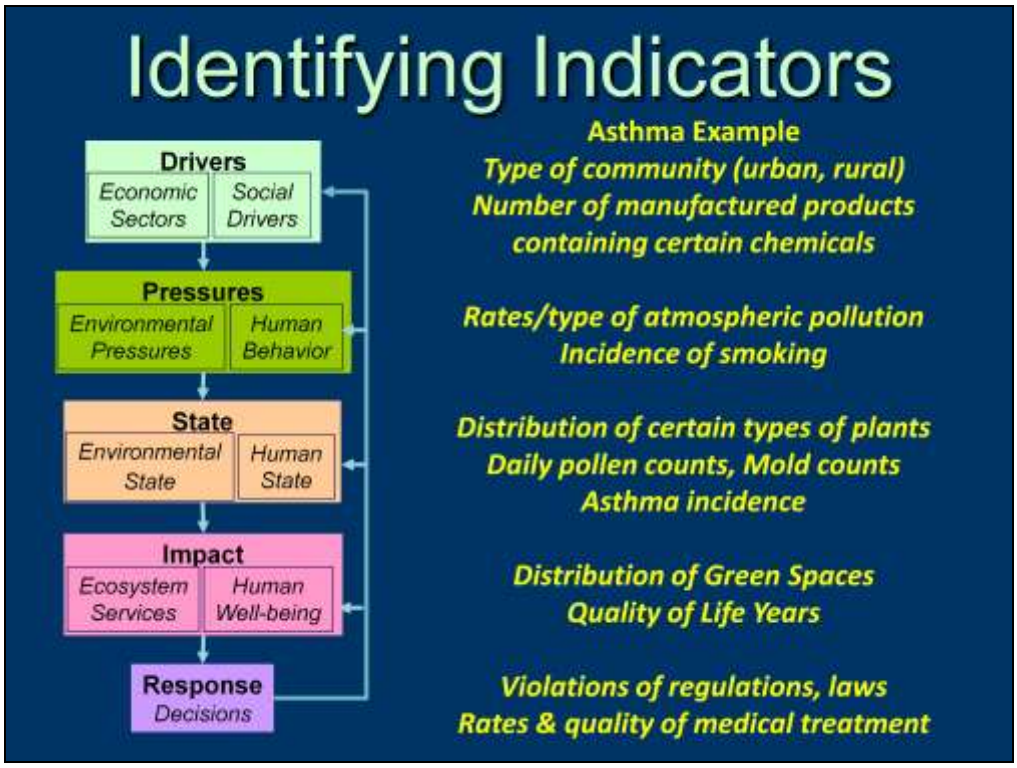



**Asthma Example: Conceptual Model**

Once key concepts are identified, the information can be diagrammed in a conceptual model.

The discussion process itself has many benefits including:

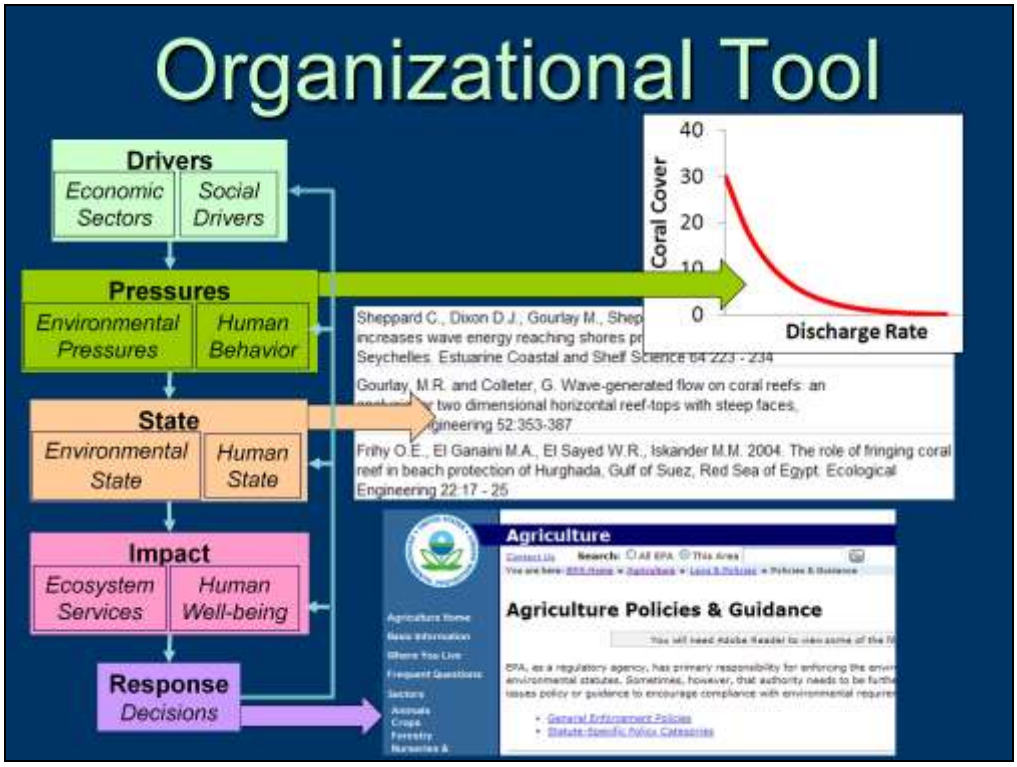
- Characterizing major stressors, interactions, and tradeoffs related to a decision
- Brainstorming or characterizing alternative decision options
- Developing measurable objectives or criteria
- Visualizing specific problems within a systems approach
- Conceptualizing interactions and needs for development of predictive mathematical models
- Enhancing communication with scientists, decision-makers, or the public




**The Integrated Framework for Identifying Indicators**

The DPSIR framework was originally developed as a framework for identifying indicators for environmental health or public health problems (DPSEEA). Once a conceptual model is agreed upon, metrics can be identified across all levels of the DPSIR, and either evaluated separately or combined to form indices related to environmental concerns, economic concerns, or social concerns.

In more formal decision analyses, DPSIR has been used as a framework for working with stakeholders to identify indices, weight stakeholder priorities, and prioritize management actions.




**The Integrated Framework as an Organizational Tool**

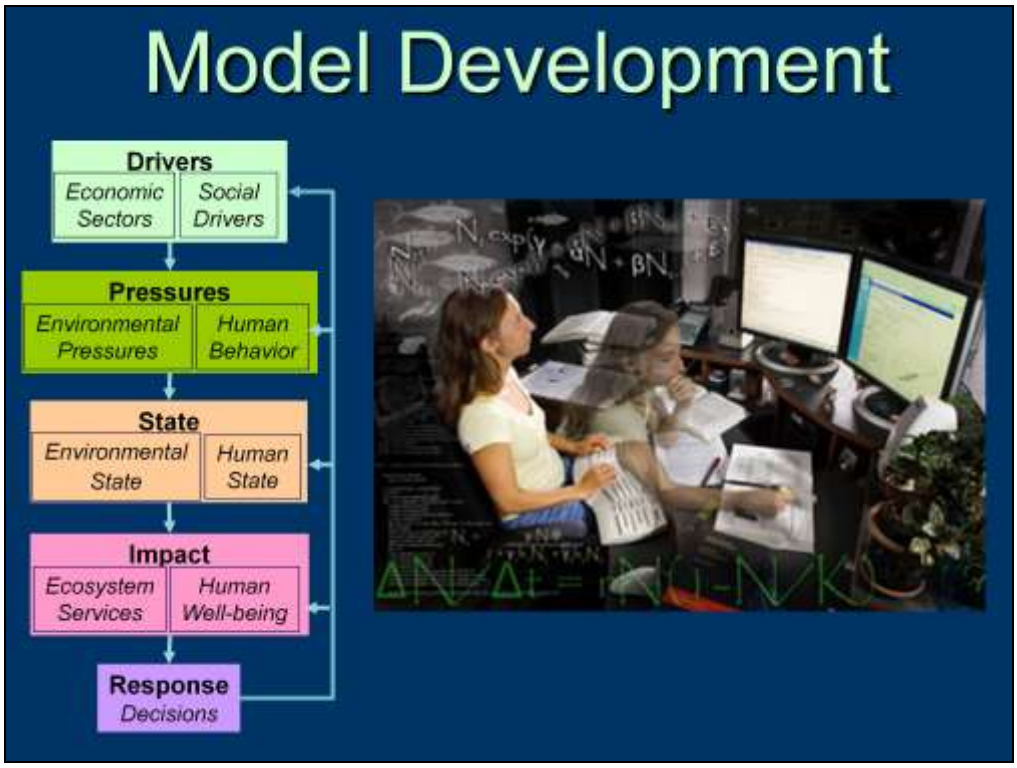
The Integrated DPSIR Framework describes the linkages among social, health, and environmental factors. Use of concept mapping software or relational database tools can allow direct annotation of DPSIR concepts with literature, science questions, research projects, collaborators, or other information.

By overlaying information on the framework, one can begin to identify potential interactions across research projects or disciplines, identify research or information gaps, and target potential collaborators to fill in missing information.

Software, such as C-map Tools software can be used to add icons which provide direct links to information from the keywords within DPSIR concept maps. Information, assigned DPSIR keywords, could also be stored in a database.

DPSIR concept maps can be used as a knowledge base for cataloguing information related including:

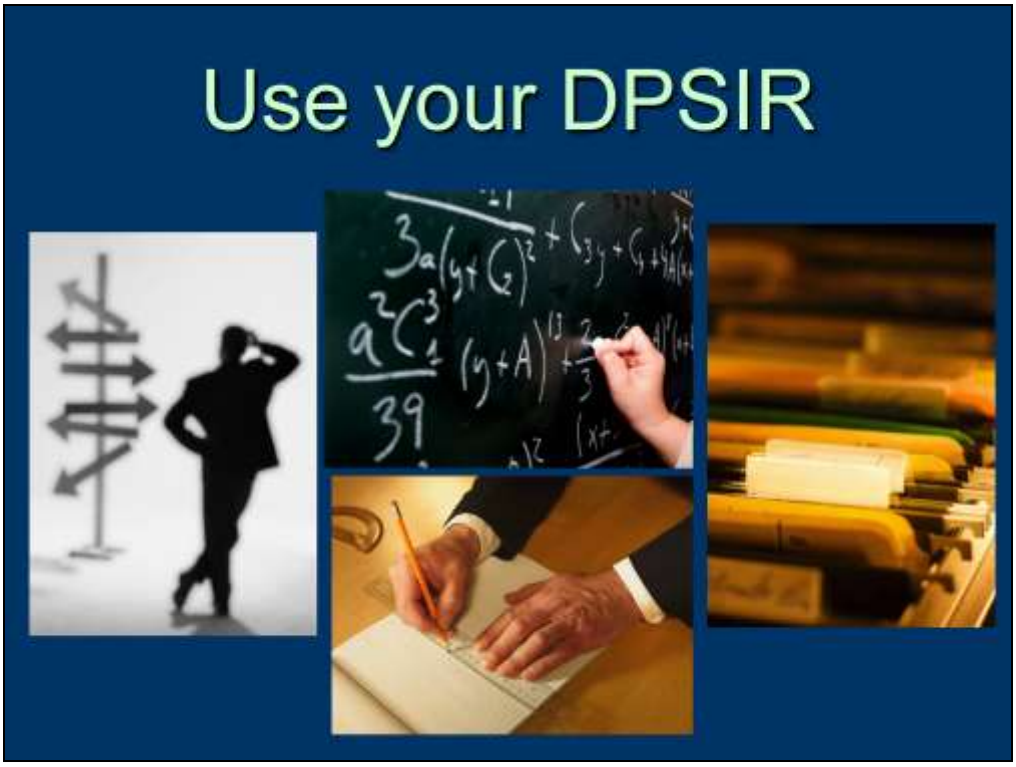
- Literature citations
- Rate functions, production functions, dose-response curves
- Images
- Legislation, regulations, and statutes
- Data and Maps
- Models
- Research projects & project leads
- Best Management Practices (BMPs)
- Contacts, partners, stakeholders




**The Integrated Framework for Model Development**

Because relational frameworks such as DPSIR, by design, hint at the dynamics of the system, they can also provide the conceptual foundation for development of mathematical simulation models for forecasting effects of alternative decision scenarios on long-term sustainability and health of communities.

Computational models for complex systems are inherently more complicated than a conceptual framework, but a framework such as the integrated DPSIR can serve to highlight key variables and relationships, for which parameter estimates and functions will be needed, and to identify areas where existing models may be appropriate or where new models are needed.




**Use your Integrated DPSIR**

We emphasize that DPSIR is just one tool in the decision-making process, but is a useful one for encouraging a systems approach to decision-making, and encouraging scientists, stakeholders, and decision-makers to think beyond their topic of expertise.