

# Design with Nature: Ian McHarg's ecological wisdom as actionable and practical knowledge



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## HIGHLIGHTS

- Ian McHarg's ecological wisdom applied in The Woodlands yields real and permanent good.
- A comprehensive design process leads to the expression and execution of Ian McHarg's ecological wisdom.
- Ian McHarg's ecological wisdom has immense relevance to contemporary design practices and urban resilience.

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## ABSTRACT

Ian McHarg's influential book *Design with Nature* (1969) synthesizes and generalizes his ecological wisdom in informing landscape planning and design. In this paper, we suggest that his design process leads to the expression and application of his ecological wisdom as actionable and practical knowledge. Key features of his design process include: (1) multidiscipline integration to provide holistic design strategies, (2) ability to tackle wicked design problems residing in a wide range of scales, and (3) targeting landscape performance in a quantitative manner. We review the development of McHarg's ecological wisdom in the context of his education, teaching, and practice, as well as the influence from scientific theories of Charles Darwin and Lawrence Henderson. Then, we illustrate McHarg's design process using The Woodlands, Texas, a 117-km<sup>2</sup> town development that McHarg considered to be the most ecologically based in the United States in the 1970s. Four decades of empirical examinations reveal the outstanding performance of The Woodlands, highlighting the credibility of McHarg's ecological wisdom. Compared with adjacent Houston communities, The Woodlands shows significantly less stormwater runoff during 100-year storms, substantially lower pollutant loadings (e.g., NO<sub>3</sub>-N, NH<sub>3</sub>-N, and TP), lower levels of forest fragmentation, an average of 2 °C lower land surface temperature, and higher walkability and pedestrian access to open space. We conclude that McHarg's design process fosters the application of his ecological wisdom in an actionable and practical manner in The Woodlands case.

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## 1. Introduction

In the history of landscape architecture, planning, and urban design, there is no lack of examples that are prominent with respect to doing real and permanent good for the human and nonhuman inhabitants, such as the Dujiangyan irrigation system in Sichuan, China (256 BCE, by Li Bing), Central Park in New York City, United States (1857, by Frederick Law Olmsted and Calvert Vaux), and the Emscher Landscape Park in Ruhr, Germany (1988, primarily through the International Building Exhibition). Designers of these projects tackled unique planning and design challenges in their time, with a common thread being the adaptive strategies

they developed that fit the site's ecological processes and cultural practices. The ecological wisdom and ingenious solutions they presented are still relevant to today's practitioners.

However, designers of these early projects may be overwhelmed by current, increasingly complex sustainability problems (Xiang, 2014). Today, landscape architects and planners face imposing challenges, such as providing resilient landscapes for a changing climate, addressing rapid urbanization, planning adaptations for natural disasters, and performing ecological restoration of degraded urban areas (Jorgensen, 2014; Nassauer, Wu, & Xiang, 2014; Steiner, 2014). An important question remains unanswered: How would the ecological wisdom residing in early projects help link knowledge to action and inform contemporary design and implementation?

This question can be answered through revisiting these prominent projects, with respect to their ideas, strategies, and successes

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and lessons learned. Landscape architects and urban planners benefit from the accumulation of wisdom from precedents, and case study presents a powerful way to inform best practices (Deming & Swaffield, 2011; Francis, 2001; Steiner, 2014; Xiang, 2014). The beauty of ecological wisdom lies in its endurance over time, efficacy in practice, and ability to predict project performance decades, if not centuries, in advance (Martin, Roy, Diemont, & Ferguson, 2010). In landscape architecture and planning, one of the most impactful body of ecological wisdom was put forth by Ian Lennox McHarg (1920–2001), in his seminar book *Design with Nature* (McHarg, 1969), in which he synthesized and generalized his experience. As the book title suggests, following nature's lead in planning and design is the wisdom of achieving sustainability. Anthropogenic uses or interventions shall become an integral part of the natural processes.

This paper focuses on three themes proposed in Xiang's (2014) editorial: Theme 2 ecological wisdom as actionable and practical knowledge; Theme 3 ecological wisdom as benchmark; and Theme 4 ecological wisdom as secret of sustained achievement (Xiang, 2014, pp. 67–68). We propose that McHarg's design process leads to the expression and application of his ecological wisdom as actionable and practical knowledge (Theme 2). Key features of his design process include: (1) multidiscipline integration to provide holistic design strategies, (2) ability to tackle wicked design problems residing in a wide range of scales, and (3) targeting landscape performance in a quantitative manner. These key features of design process help establish landscape performance benchmarks (Theme 3), and show how the processes of McHarg can result in real and permanent good, while not all processes do so (Theme 4). We highlight McHarg's nature-led design in a 117-km<sup>2</sup> town development, The Woodlands, Texas, whose town plan McHarg considered to be the most ecologically based plan in the United States in the 1970s.

## 2. McHarg's ecological wisdom in context

In more than ninety projects, as elaborated in *Design with Nature* (e.g., chapter 10, "Processes as Values"), McHarg seeks the intrinsic carrying capacity of land through a design process that respects, integrates, and facilitates multiple ecosystem processes, functions, and services. McHarg's ecological wisdom of "following nature's lead in design," however, does not emerge in vacuum. His education at Harvard University, teaching at the University of Pennsylvania, and 18 years of practice at Wallace McHarg Roberts and Todd (WMRT) culminated in the peak phase of his legendary career.

McHarg pursued joint degrees in landscape architecture and city planning at Harvard in the 1940s. At that time, there was continual separation between the two programs. Most landscape architecture faculty remained focused on small-scale garden and park design, whereas city planning faculty were interested in broad social and environmental issues. McHarg's passion and training in both programs allowed him to embrace diverse planning and design scales when developing his own ecological planning theory and practice, something that most landscape architects at that time were not able to do (McHarg, 1996; Spirn, 2000).

McHarg continued to bridge the separation through his teaching at the University of Pennsylvania. He integrated regional planning and landscape architecture, particularly through his incorporation of environmentalism into studio teaching to achieve a more holistic pedagogical approach (Spirn, 2000). Emphasis was placed on understanding the natural processes. In McHarg's first studio project (Cape Hatteras) in 1956, for instance, students examined the processes of beach formation and erosion, the development of plant communities and animal habitats, and the interactions among them (McHarg, 1996; Spirn, 2000). A number of other case studies were examined in *Design with Nature*, included the Delaware River

Basin Study, Interstate 95 in New Jersey, Staten Island Project, and Plan for the Valleys. The case studies demonstrated the imperative of interdisciplinary collaboration, in order to incorporate natural processes (biophysical attributes) and social and cultural issues in the design process (McHarg, 1996; Toth, R., personal communication, July 20, 2014).

Furthermore, McHarg used his department chair position at Penn to hire many natural scientists and social scientists, as well as leading designers on the faculty, to promote interdisciplinary collaboration in design studios, such as Laurie Olin, Robert Hanna, Sir Peter Faulkner Shephard, Carol Franklin, A.E. Bye, Karl Linn, and others. In 1962, McHarg hired a forester and resource economist, Dr. Nicholas Muhlenberg. Since then, "the biome, the physiographical region, and the river basin provide an indispensable context for the curriculum at Penn" (Spirn, 2000, p. 104).

McHarg taught another noteworthy course, Man and Environment, throughout the 1960s and 1970s, and some of the most distinguished scholars in the environmental era were invited to lecture (McHarg, 2006a), such as Lewis Mumford, who wrote the Introduction to *Design with Nature*, and Eugene Pleasants Odum and Howard Thomas Odum, who heavily influenced McHarg's knowledge of ecosystem ecology. In 1963, eight of the lecturers were Nobel Prize winners (Spirn, 2000). Based on this course, McHarg hosted a CBS television series (*The House We Live In*) from 1960 through 1961, and invited leading scientists of the time (e.g., Margaret Mead, Loren Eiseley, and Luna Bergere Leopold). The course and the CBS television series facilitated the development of McHarg's theoretical framework and scientific ideas for his book *Design with Nature* and his wisdom in ecological planning and design (McHarg, 1996; Spirn, 2000).

After the CBS television series, McHarg began to gain national recognitions outside the landscape architecture field. Particularly after 1962, McHarg played an increasingly important role in developing the intellectual base and methodological framework for the National Environmental Policy Act (NEPA) (McHarg and Steiner, 1998). McHarg's interdisciplinary approach to ecological planning and his systematic evaluation of the plan formed a standard practice in NEPA, and this is particularly reflected in the Environmental Impact Statement (EIS) (Bass, Herson, & Bogdan, 2001).

In 1962, McHarg began to test his ecological planning methods on real clients and projects. Subsequently, his studio at Penn became a place in which to experiment with theories, and McHarg's firm, WMRT, provided a means to test the theories. The types of clients and projects with which McHarg (WMRT) worked were influenced by several federal acts enacted during the environmental era (Table 1). The evaluation and mitigation of environmental consequences due to suburban and exurban growth constituted the majority of McHarg's professional work in the 1960s and 1970s (Spirn, 2000; Steiner, 2011). By 1969, Penn's Department of Landscape Architecture and WMRT enjoyed worldwide reputations as a leading landscape architecture program and firm, respectively (McHarg, 1996; Spirn, 2000).

In addition to a successful practitioner, McHarg was a theorist. He developed his own theory of "creative fitting," which explained and validated his nature-led design approach (Herrington, 2010; McHarg, 1996). The inspirations were attributed to the scientific theories of Charles Darwin's *The Origin of Species* (Darwin, 1859), which suggests that "the surviving organism is fit for the environment" (McHarg, 2007, p. 23), and Lawrence Henderson's *The Fitness of the Environment* (Henderson, 1913), which indicates that "the actual environment, the actual world, constitutes the fittest possible abode for life . . . this fitting then is essential to survival" (McHarg, 2007, pp. 23–24). In addition to Darwin, Henderson, and the Odums, McHarg's ecological ideas were also influenced by Patrick Geddes, Loren Eiseley, Robert MacArthur, John Phillips, and Jack McCormick, among others.

**Table 1**  
Ian McHarg's (WMRT's) primary project types during 1960s–1970s (Spirn, 2000; Steiner, 2011).

Period	Primary project type	Federal act
1960s	Rural areas in metropolitan regions impacted by federal highways	Interstate Highway Act 1956
Late 1960s–early 1970s	Planned new communities and resorts (client: private developers)	New Communities Act 1968
Mid 1970s–1979	Control and direct growth for environmental quality issues (client: public agencies)	National Environmental Policy Act 1969 Clean Water Act 1972

In accord with his theory of “creative fitting,” McHarg provided his definition of ecological design: “Ecological design follows planning and introduces the subject of form. There should be an intrinsically suitable location, processes with appropriate materials, and forms. Design requires an informed designer with a visual imagination, as well as graphic and creative skills. It selects for creative fitting revealed in intrinsic and expressive form” (McHarg, 2006b, p. 123).

Other lasting contributions that McHarg made are his definition of *nature* as a process that “is subject to the forces that produce and control the phenomena of the biophysical world” and his statement that places are “only comprehensible in terms of physical and biological evolution” (Herrington, 2010; McHarg, 1969, p. 105). Following this definition of *nature*, McHarg stated that design process should fit in the natural processes and that, “We have asked Nature to tell Man what it is, in the way of opportunities and of constraints for all prospective land-uses” (McHarg, 2007, p. 44). Because most of McHarg's projects are located in suburban and exurban areas that are low density and less populous, understanding the natural processes (biophysical attributes) becomes the key to project success.

As a result, nature as a value system and the ecological and natural sciences (the field of ecology in particular) provided the theoretical core for McHarg's ecological planning and design method. His design process is operationalized by the landscape suitability assessment framework (“layer-cake” model for mapping). The design process starts with a comprehensive ecological inventory, in which natural processes are integrated into planning and design. Ecological factors are superimposed onto the land to determine its capacity to support human activity and its suitability for a particular type of land use (McHarg & Steiner, 1998). This design process lays out a systematic analytical framework that is instrumental in identifying central design problems of the site, as illustrated in the following case study.

### 3. Case study of The Woodlands, Texas: actionable ecological wisdom

The Woodlands, Texas, is a 117-km<sup>2</sup> town development that McHarg considered to be the most ecologically based in the United States in the 1970s. The Woodlands is located 50 km north of Houston. It currently has eight subdivision residential villages with a total population of 125,000 (<http://www.thewoodlandstx.com/demographics/>). The Woodlands has received numerous awards, such as a prestigious Sixth Annual Biennial Award from the U.S. Department of Housing and Urban Development (HUD) in 1974 for its great success in environmental planning (Morgan & King, 1987). Nevertheless, its planning innovations would not be realized without McHarg's ecological wisdom.

#### 3.1. The Woodlands project background

Scoping of The Woodlands project started in the early 1960s, a period when suburban development has been criticized for causing ecological damage and environmental degradation. Early generations of new town development (Reston, Virginia, and Columbia,

Maryland) created considerable interest and were considered to solve America's urban problems (Ewing, 1997; Forsyth, 2002; Spirn, 1984). The 1960s and 1970s also marked a peak of environmental sensitivity, particularly following the passage of the NEPA. Environmental impact analysis was not emphasized in the above earlier new towns, but it was a heavy focus in The Woodlands (McHarg & Steiner, 1998).

In 1970, the Urban and New Community Development Act was passed, and under its Title VII, the HUD was authorized to provide loan guarantees of a maximum of \$50 million to new town developers. A total of thirteen Title VII new towns were approved, including The Woodlands, and EIS were required for all of them (McHarg & Sutton, 1975; Steiner, 1981). Developer George Mitchell turned to McHarg because of WMRT's reputation in environmental planning (Morgan & King, 1987).

#### 3.2. Unique design challenges

Designers faced challenges in land development and drainage design. The lush pine forest made The Woodlands an attractive place for development. However, about one third of the site lies within the 100-year floodplains of the three creeks on site, making developable land limited. The poorly draining soils and extremely flat topography caused drainage problems (WMRT, 1973a). During the site visits, McHarg and his WMRT colleagues found that in adjacent developments, concrete ditches were constructed to facilitate runoff. However, this conventional solution further lowers the groundwater table and causes trees to die.

The Woodlands lies on top of the recharge areas for aquifers that underlie Houston. Some areas in Houston had already subsided by approximately 3.1 m because of oil and water extraction (Spirn, 1985). If conventional drainage solutions are used, The Woodlands development may further threaten the support of high-rise buildings in downtown Houston. The annual precipitation of Houston area is around 840 mm, whereas coastal hurricanes usually cause widespread flooding by generating intense rainfalls in single events. Thus, if conventional development were used in The Woodlands, it would have increased the severity and frequency of floods in Houston downstream (McHarg, 1996). As McHarg recalled, each of these challenges required a novel approach in land planning.

#### 3.3. McHarg's (WMRT) design process and holistic solution

The above-cited planning challenges are wicked in nature (Rittel & Webber, 1973; Xiang, 2013), because urbanization inevitably increases runoff and flooding potential and degrades water quality. Adaptive strategies should be developed to accommodate and minimize these impacts. McHarg's design process has several interwoven, reiterative steps, with key steps as illustrated in Fig. 1. This process demonstrates an interdisciplinary team approach for planning and design, in lieu of a plan produced by a single designer. The process starts with a comprehensive ecological inventory of the site, followed by data interpretation and (re)prioritization of goals and objectives. Based on a series of map overlays, various factors such as ecological, economic, and political issues are superimposed to determine the land's carrying capacity to support certain human

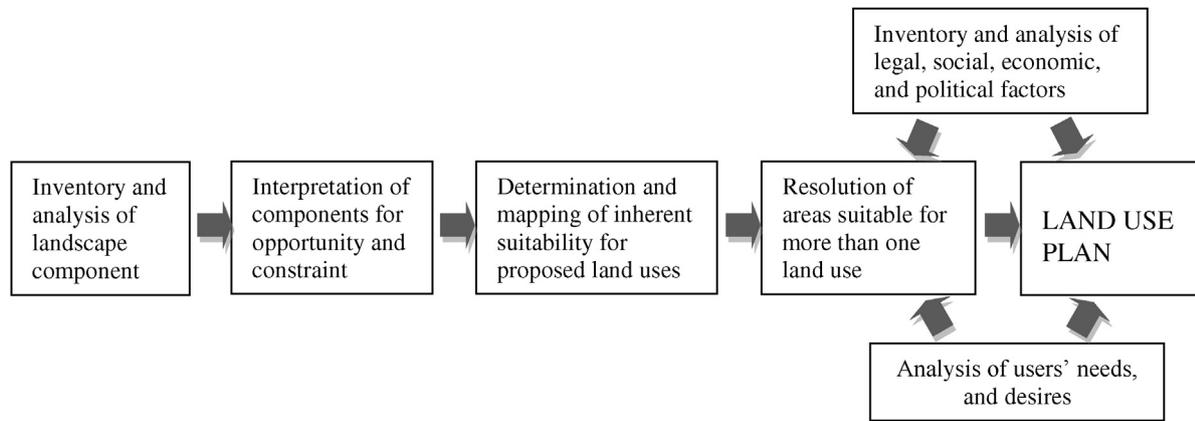


Fig. 1. Flow chart of the ecological planning process in The Woodlands. Adapted from Johnson, Berger, and McHarg (1979), McHarg and Steiner (1998, p. 244), Fig. 1.

activities and land uses (primarily residential in The Woodlands). Four polished reports were produced (WMRT, 1973a, 1973b, 1973c, 1974), and these innovative studies became one of the early EISs of the NEPA process.

The emphasis on process rather than a prescribed plan product is important. The regional effects of land development on groundwater, in particular, would not have been identified with a less-comprehensive approach to study The Woodlands site. An interdisciplinary team was essential to this study approach. The WMRT team conducted an ecological inventory that described the existing natural phenomena, including geology, groundwater hydrology, surface hydrology, limnology, pedology, plant ecology, wildlife, and climatology (Table 2). This study of natural features and processes revealed important issues of which George Mitchell's staff were unaware initially. As aforementioned, a study showed the regional aquifer system beneath The Woodlands and Houston (Fig. 2), which suggested that runoff from upstream areas needed to infiltrate and percolate into the ground to sustain two aquifers that provide water for Houston. Through this process of examining the regional effects, it also became apparent that surficial hydrology, soils, and vegetation constituted a closely linked system. The development of adaptive strategies that augment the function of this linked system is crucial (McHarg & Steiner, 1998; WMRT, 1973a). As a result, central problems identified from this design process included stormwater drainage, flooding, and groundwater recharge.

To tackle these central problems and to meet the planning goal of preserving the pine forest, several integrated planning strategies were developed to maintain the site's natural hydrologic balance (WMRT, 1973b, 1974). The main strategies were to: (1) preserve land with highly permeable soils, (2) maintain forest preserve land, and (3) use natural surface drainage. In addition, these integrated strategies were implemented through a holistic "natural" drainage scheme to tackle wicked design problems (e.g., drainage design, flood control, and groundwater recharge) residing in a wide range of scales. Fig. 3 shows regional-scale analysis of the biophysical features and the proposed development, in which densities and locations are largely determined by soil patterns to allow maximum runoff infiltration (WMRT, 1973a, 1973b, 1973c, 1974). At the site level, adaptive design strategies are specified for soils and housing development (Table 3, Figs. 4 and 5).

As a result, the "natural" drainage scheme determined the overall layout and structure of The Woodlands. Collector streets, neighborhood roads, and commercial buildings were placed on ridgelines and higher elevations. The 100-year floodplains of three creeks on site were preserved, as were sandy soils in parks and public right-of-way. Check dams were built to retard runoff along open drainage channels. Golf courses, parks, and open space detain

runoff over sandy soils to enhance infiltration (McHarg, 1996; Spirm, 1985; WMRT, 1973b). Fig. 6 shows the built conditions following WMRT's design strategies.

Thus, The Woodlands design process reveals a dynamic framework from data analysis, synthesis, and interpretation, to planning, design, and implementation. This design process illuminates central problems, reveals interactions of issues, informs possible design interventions with corresponding outcomes (development scenarios), and facilitates the integration of design solutions at both regional- and site-level scales. These strategies and examples (i.e., Table 3, Figs. 3–6) show that McHarg's design process forged actionable steps in practice, in that landscape architects and planners essentially need to give physical forms to a land or space in a spatially meaningful way.

Furthermore, McHarg's design process allows the targeting of landscape performance benchmarks quantitatively. As McHarg and Sutton stated in a 1975 article, "It is the quantitative capabilities of the method which deserve the greatest attention and refinement. While the data and the hypothesis employed in formulating the conclusions await testing, they represent a dimension of causality and quantification not heretofore accomplished in any projects by WMRT" (McHarg & Sutton, 1975, p. 90). To its credit, The Woodlands' landscape performance has been assessed in a number of scientific studies conducted in the past four decades, highlighting the credibility of McHarg's ecological wisdom.

#### 3.4. Scientific proof of McHarg's ecological wisdom

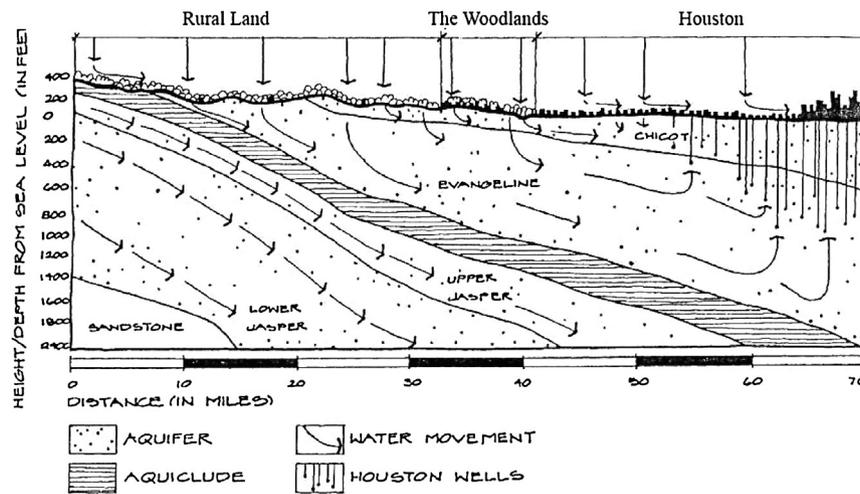
The Woodlands survived storms that exceeded a 100-year level in 1979 and a 500-year level in 1994 with little property damage, while Houston (50 km away) was severely flooded during both events (Girling & Kellett, 2005). In a tropical storm in 1987, two adjacent communities (Oak Ridge North and Timber Ridge) were awash, while The Woodlands survived unscathed. In addition to these testimonies, Table 4 summarizes empirical studies conducted on The Woodlands, presented in 11 metrics that cover environmental, social, and economic aspects of sustainability. These findings present considerable similarities with what McHarg and his colleagues have envisioned or forecasted, suggesting that WMRT's plan successfully achieved the planning goal.

Compared with adjacent Houston communities, The Woodlands shows significantly less stormwater runoff during 100-year storms, substantially lower pollutant loadings (e.g.,  $\text{NO}_3\text{-N}$ ,  $\text{NH}_3\text{-N}$ , and TP), lower levels of forest fragmentation, an average of  $2^\circ\text{C}$  lower land surface temperature, and higher walkability and pedestrian access to open space (see Table 4). For instance, McHarg's (WMRT) plan predicted that peak flows in The Woodlands would increase by 55%, versus 180% in Houston conventional development (Juneja

**Table 2**  
Selected inventory maps in The Woodlands project.

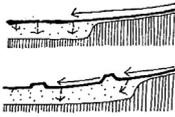
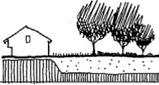
	Category	Detailed item
1	Physiography	Elevation, slope
2	Geology	Bedrock or subsurface geology, surficial deposits, geological cross-sections
3	Soils	Series or phases, drainage classes, hydrologic groups, capability group, depth to seasonal high water table, as applicable
4	Hydrology	Depth to water table, aquifer yields, direction of groundwater movement, recharge areas, water quality, surface waters (lakes, streams, wetlands), flood zones, drainage basins
5	Vegetation	Distribution of associations, communities, and habitats as identifiable, areas important as noise buffers, food supplies, for wildlife, nesting areas
6	Wildlife	Identification of species and their habitats and ranges, movement corridors
7	Climate	Macro- and microclimate parameters (temperature, moisture, wind). Ventilation and insulation may be determined in conjunction with physiography
8	Resources	Mineral or other valuable natural resources

Adapted from McHarg & Steiner, 1998, p. 245, Table 6.



**Fig. 2.** Regional study of the Chicot and Evangeline aquifers underlying Houston and The Woodlands, Texas. Adapted from Spirn (1984, p. 164), Fig. 7.10. Used by permission.

**Table 3**  
The Woodlands site planning guidelines and adaptation strategies for soils (WMRT, 1973b, p. 11).

Objective 1 Adaptations Direct runoff over permeable soils with excess storage capacity. Use roads, berms, and checkdams in swales to impound runoff by blocking flow over permeable soils.	Use recharge capacities of suitable soils to enhance a natural drainage system and even out base flow of streams. 
Objective 2 Adaptations Locate structures on impermeable soils. Locate backyards and intensively used recreation areas on permeable soils.	Minimize coverage on top of permeable soils. 
Objective 3 Adaptations Buildings and patios should be constructed on raised foundations or fill.	Houses and outdoor activity areas should be located to be as dry as possible. 
Pedestrian paths should be raised or on fill if located on impermeable soils.	

& Veltman, 1980; Spirn, 1984, 2000; WMRT, 1973a, 1973b, 1973c, 1974). Using observed data and coupled with computer simulations, several studies show that The Woodlands peak flows are 2–3 times lower than conventional Houston development (Doubleday,

Sebastian, Luttenchlager, & Bedient, 2013; Yang & Li, 2010, 2011; Yang, Li, & Li, 2013).

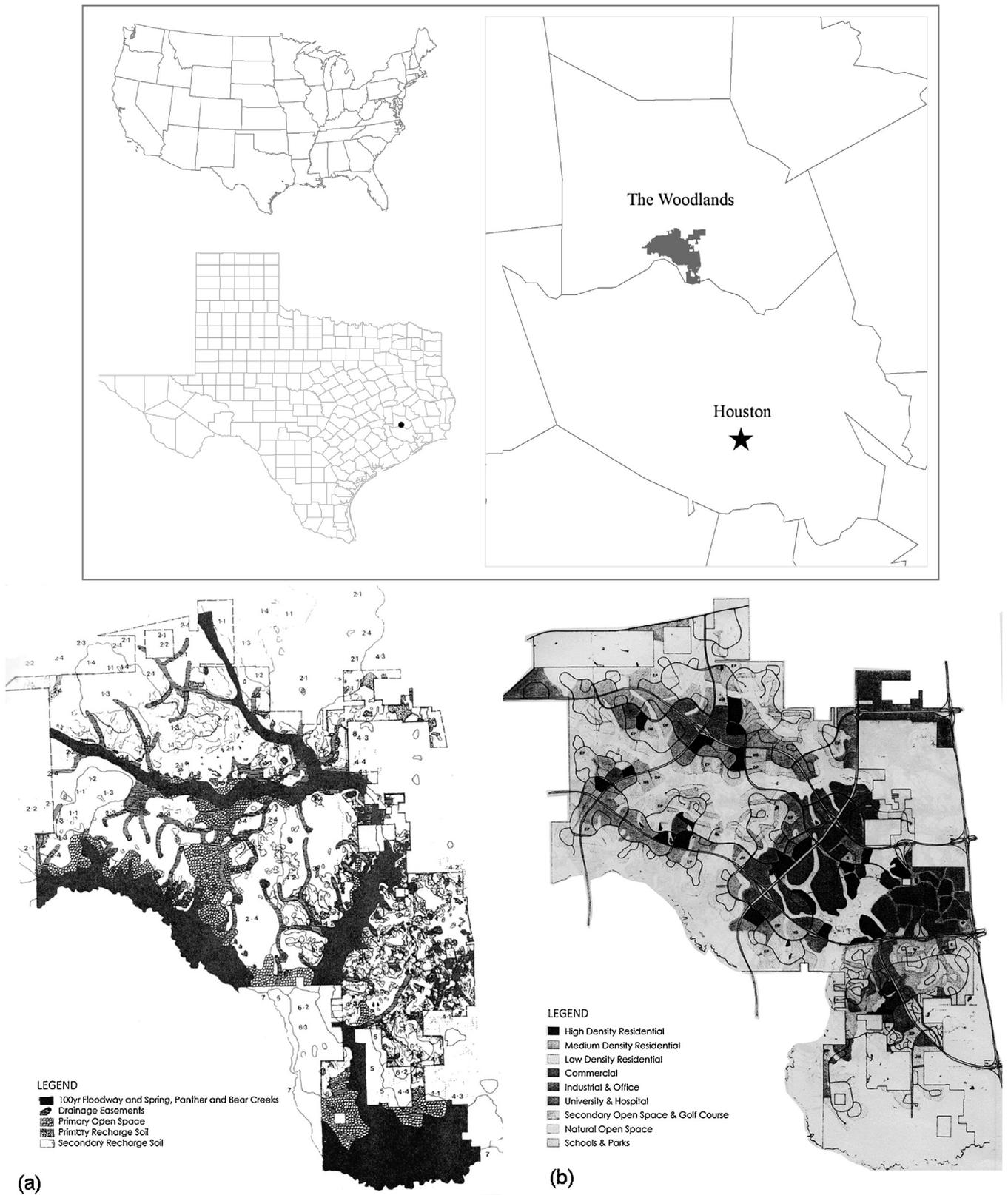
More importantly, several of McHarg’s unique planning concepts have proved to be successful. It is efficacious to use soil

**Table 4**  
Integrated planning and design in The Woodlands: metrics, strategies, and performance forecasts in Ian McHarg's (WMRT's) original plan and empirical examinations decades later. Landscape performance is in accord with WMRT's projections.

Metric	WMRT strategies, performance forecast	Reference	Empirical analysis decades later	Reference
1. Stormwater runoff	Link soil permeability with housing density; would generate lower runoff than conventional development	WMRT (1973c), McHarg and Sutton (1975), Juneja and Veltman (1980)	The Woodlands land use plan minimizes the hydrologic impacts; lower runoff than conventional Houston communities	Juneja and Veltman (1980), Bedient, Flores, Johnson, and Pappas (1985), Yang and Li (2010, 2011), Doubleday et al. (2013), Yang et al. (2013)
2. Flood control	Predicted peak flows increase by 55%, versus 180% in Houston's conventional development	WMRT (1973a, 1973b, 1973c, 1974), Juneja and Veltman (1980), Spirn (1984, 2000)	Peak flows 2–3 times lower than conventional development; peak flows similar to forest conditions during 100-year storms, and would be 50% lower if strictly followed McHarg's approach	Doubleday et al. (2013), Yang and Li (2010, 2011), Yang et al. (2013)
3. Water quality	Open drainage, wetland, permeable pavement, building construction BMPs <sup>a</sup> ; lower pollutant levels than Houston's conventional communities	WMRT (1974), Juneja and Veltman (1980)	Pollutant loadings (NO <sub>3</sub> -N, NH <sub>3</sub> -N, and TP) are substantially lower than Houston communities <sup>b</sup>	Yang and Li (2013)
4. Water conservation	Minimize irrigation water use through limiting lawn areas and irrigated public space	Spirn (1984, 1985), Kutchin (1998)	n/a	n/a
5. Forest protection	Large, permanent forest preserve; tree protection at street right-of-way and individual parcels	WMRT (1973a, 1973b, 1973c, 1974), Spirn (1984)	Lower levels of forest fragmentation than North Houston communities; 25% land preserve as open space in perpetual	Morgan and King (1987), Galatas and Barlow (2004), Kim and Ellis (2009)
6. Wildlife	Preserve continuous wildlife corridors at wetlands and floodplains	WMRT (1973b, 1974)	Wildlife corridor and forest connectivity well preserved	Spirn (1984), Forman (2002), Kim and Ellis, 2009
7. Urban heat island	Not a focus area in WMRT plan	n/a	On average 2 °C lower land surface temperature than Houston communities	Sung (2013), Yang et al. (2013)
8. Energy conservation	Solar panel application; planting design and housing orientation strategies	Kutchin (1998), Galatas and Barlow (2004)	n/a	n/a
9. Social value	Integrate ecological and social goals; use of floodplains and drainage channels as open space	WMRT (1973b), Spirn (1984)	Good ethnical diversity and integration; rich social events and community employment opportunities; good stand of resident's satisfaction and well-being	Morgan and King (1987), Galatas and Barlow (2004), Forsyth (2002, 2003, 2005), The Woodlands Township (2011)
10. Transportation	Not a focus area in WMRT plan	n/a	Better interconnectedness, higher walkability than conventional Houston communities	Zhang and Yi (2006)
11. Cost benefit	Would save \$14 million for Phase I alone; low maintenance parkland and residential yards	McHarg and Sutton (1975)	Potential avoided costs include flooding damage and salvation, personnel injuries, erosion and sediments control, and water quality pollutants treatment; increased housing value due to park and open space	Yang and Li (2010, 2011), Yang et al. (2013), The Woodlands Township (2011)

<sup>a</sup> BMP (Best Management Practice). Construction fencing is usually only a few feet away from the building footprint to ensure minimum site disturbance.

<sup>b</sup> NO<sub>3</sub>-N (nitrate-nitrogen); NH<sub>3</sub>-N (ammonia nitrogen); TP (total phosphorous).



**Fig. 3.** (1) Location map of The Woodlands, Texas, USA. (2) Community-scale analysis of The Woodlands (a) Design synthesis (WMRT, 1974, p. 35) and (b) proposed land use plan (WMRT, 1974, p. 41). The proposed development locations are largely determined by soil patterns to allow maximum runoff infiltration.

permeability as a key variable to guide land use planning to achieve the zero-runoff objective (Yang & Li, 2011). The holistic, “natural” drainage system demonstrated flood mitigation effectiveness in

that the runoff regimen retains its forest conditions after development.

Apparently, a holistic solution serves many purposes (see Table 4), and this solution benefits not only The Woodlands but

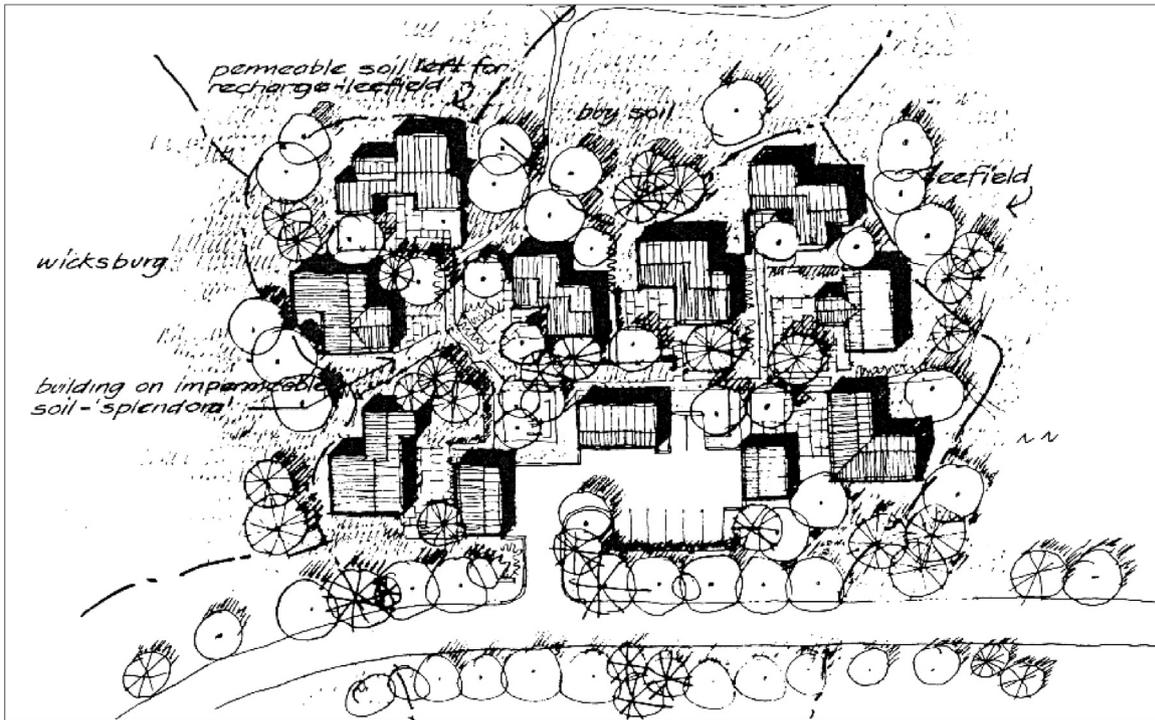


Fig. 4. Site-level design guidelines. Housing cluster and grouped parking conformed to the boundaries of soils with low infiltration capacities (WMRT, 1974, p. 72).

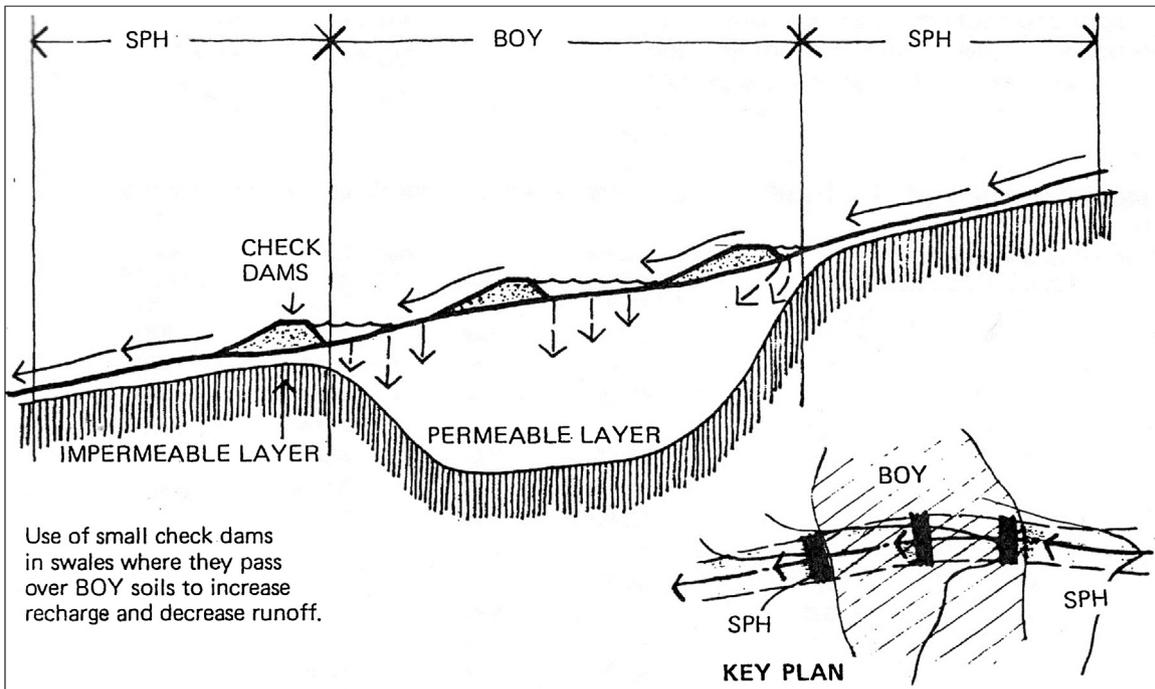
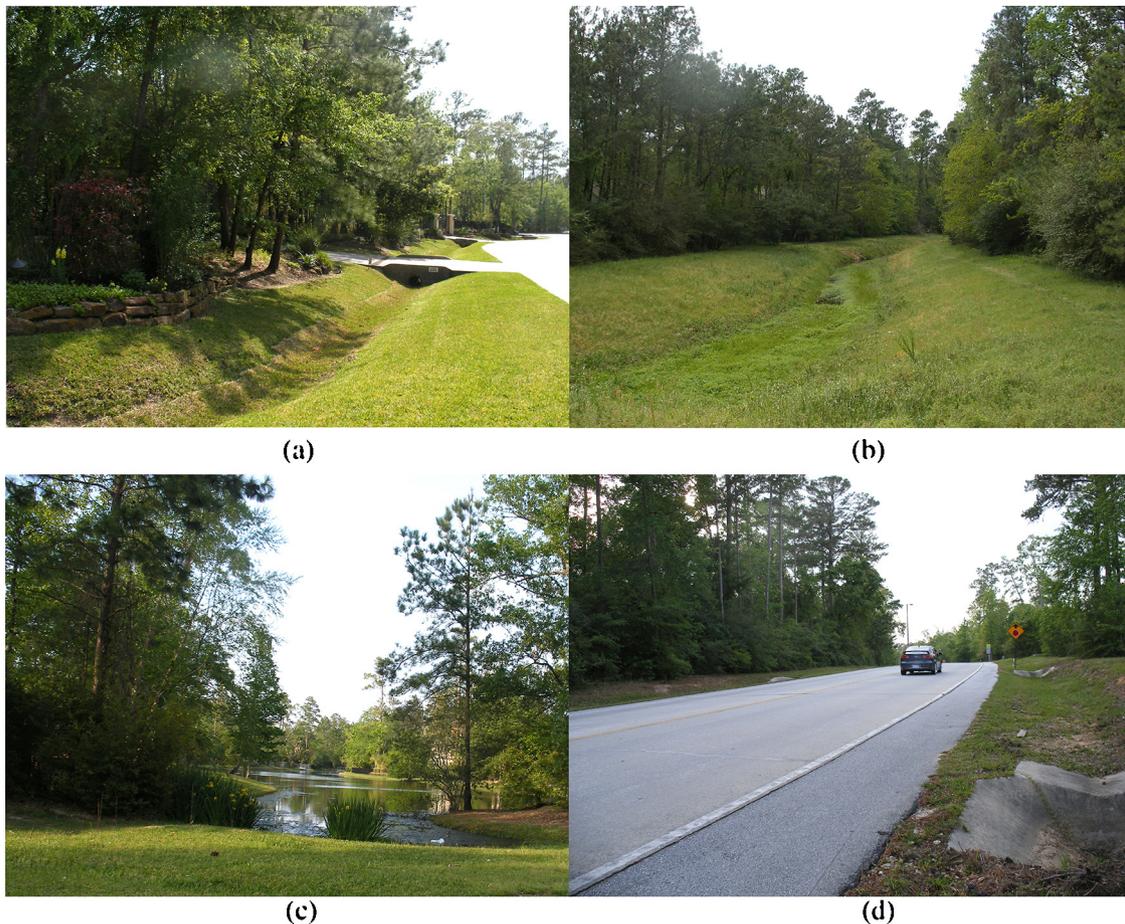


Fig. 5. Open surface drainage along collector streets. Design guideline promotes impoundment on permeable soils. Check dams retard runoff and increase infiltration. BOY: medium to well-drained soil; SPH (Splendora): poorly drained soil (WMRT, 1973b, p. 31).

also the Houston region’s sustainability in the long run. The sum of the benefits brought about by a holistic solution is more than those of its pieces. However, a holistic solution is arguably one-of-a-kind for a particular site—to tackle specific (wicked) design problem(s). In The Woodlands, it was the design process that led to the identification of central problems. McHarg considered his approach as “diagnosis and prescription” for land planning (Spirn, 2000). And

he believed that it was an objective procedure used in The Woodlands that could be replicated to produce similar outcomes: “A method was developed which insured that anyone would reach the same conclusions... any engineer, architect, landscape architect, developer, and the client himself were bound by the data and the method” (McHarg & Sutton, 1975, p. 78).



**Fig. 6.** Drainage and landscape design conditions in The Woodlands: (a) open surface drainage swale with trees preserved in subdivisions, (b) natural vegetation well preserved along creeks, (c) natural bank with well-preserved vegetation along ponds, and (d) collector street with check dams that retard runoff and encourage impoundment on soils with good infiltration capacity (Also see Fig. 5 site design diagram).

#### 4. Discussions

Through revisiting one of McHarg's most successful projects, The Woodlands, we suggest that his ecological wisdom presents a knowledge/skill component, as well as a value system that embraces cultural, personal, and ethical characteristics. Discussions below elaborate on how McHarg's comprehensive design process would make his ecological wisdom actionable and facilitate the establishment of landscape performance benchmarks. In addition, we speculate on why McHarg can do real and permanent good, while some others cannot.

##### 4.1. Holistic design solution for multifunctional landscape

Empirical evidence shows that The Woodlands plan presented multifunctional benefits. The "natural" drainage system exemplified the advantages of integrating stormwater drainage, flood control, and water quality. This system presents resilience to flood (or drought) because the WMRT plan caused little alteration to, and, in fact, enhanced the hydrologic system that existed before construction of the The Woodlands. The solution was also a low-cost, low-maintenance one (Spirn, 1985; Yang et al., 2013). Interestingly, The Woodlands also demonstrated excellent performance in some metrics (e.g., pedestrian accessibility, urban heat island effect mitigation) that were not focus areas in the WMRT plan.

The holistic design started with an understanding of the natural processes, followed by seeking adaptive fitting of these processes (McHarg's theory of "creative fitting"). McHarg's ecological wisdom

was to tackle the overriding design problems, while the solution incorporated other concerns in addition to the principal ones. This created "a holistic appreciation for nature and fosters designs that transcended narrow temporal and spatial limits" (Spirn, 1985, p. 42). Hence, The Woodlands highlighted McHarg's ecological wisdom and theory that planning and design are a tool of human evolution. The WMRT plan for The Woodlands expressly used the term *evolution*, meaning creative fitting and adaptation. Planning and design guidelines took the form of "adaptive strategies" (see Table 3), and the analysis of ecological processes "determined the form of the Woodlands" (McHarg & Sutton, 1975).

##### 4.2. Why McHarg's projects can do real and permanent good

McHarg's idea of incorporating nature into the design process set the premise for the planning and design professionals. His ability to do real and permanent good could be attributed to his knowledge and skill set in planning and design, his broad influence outside the landscape architecture and planning disciplines, and his faculty position at a prestigious academic institution.

McHarg presents core problem-solving skills in ecological design. He is proficient in multiple-scale synthetic thinking and his critical thinking skill-sets allow him to assemble the right colleagues to consult and work with (e.g., his interdisciplinary team approach). He is also capable of interpreting complex ecological data and (re)prioritizing design goals to recast simple(r) design problems.

**Table 5**  
Selected significant projects of Ian McHarg (WMRT) and their implications to contemporary practice.

Project	Central theme/major design question	WMRT design innovation	Impact on contemporary theory or practice
Plan for the Valleys (1962)	Illustrate consequences of uncontrolled vs. planned growth, and potential economic profitability	Integrate graphic presentation and economic analysis; visualize impacts of different built scenarios	Today's land trusts, purchase and transfer of development rights, performance zoning
Potomac River Basin (1965)	Provide a framework for development (past, present, and future, at multiple landscape scales)	First study to combine the physiographic region and the river basin as the organizing context for ecological planning and design; used most of the methods (overlay and metrics) at the time	Institutionalizes a comprehensive method for ecological inventory; advances GIS method
The Woodlands (1973)	Plan at a flood-prone site coupled with difficult drainage conditions; maintain aquifer levels to prevent Houston high-rise buildings from sinking	A holistic solution of natural drainage system integrating stormwater drainage, flood control, and water quality; link soil permeability to development intensity	One of the first applications of GIS to a built project; precursor of USEPA's LID and GI initiatives; today's "green-street" programs nationwide <sup>a</sup>

<sup>a</sup> USEPA (U.S. Environmental Protection Agency); LID (low-impact development); GI (green infrastructure).

In addition, McHarg "is among the very few landscape architects since Frederick Law Olmsted Sr. who have commanded widespread notice, respect, and influence outside the design and planning fields" (Spirn, 2000, p. 97). His 1969 book *Design with Nature* is considered as the most influential text in the planning and design discipline in the 20th century. The book was also selected as a finalist of the 1969 National Book Award. His theory and methodology pervaded beyond NEPA into other federal and state environmental management programs (Bass et al., 2001). Besides his 1960–1961 CBS series ("The House We Live In"), his successfully co-organized the 1970 Earth Day event, in which more than 30,000 people participated (McHarg, 1996). McHarg also appeared frequently on television and in popular press. For instance, he helped produce and starred in the popular 1969 public television documentary "Multiply and Subdue the Earth." His charismatic personality and superb capability to communicate in layman's language persuaded numerous individuals to accept his ideas (Spirn, 2000).

Another important aspect of McHarg's career was that he had extensive involvement in actual planning and community design projects. These opportunities allowed him to constantly link theory to practice and to refine his ideas and methods (McHarg & Steiner, 1998). McHarg's faculty position at Penn allowed him to structure his teaching and practice in a complementary way. During his eighteen years with WMRT, the creative tension between theory (Penn teaching) and practice (WMRT) led to exciting innovations in ecological planning and design. A practicing landscape architect is often constrained by the prescribed project scope. In contrast, McHarg's faculty position allowed him to choose problems that he deemed important to examine (Spirn, 2000).

For The Woodlands project, it is also important to mention that its success was attributed to several other important factors, in addition to McHarg's (WMRT) plan. These factors are developer George Mitchell's vision of resolving America's urban problems and his financial support, the \$50 million HUD loan guarantees, and the relatively flexible planning system in the 1970s (Yang, Li, & Huang, 2015).

#### 4.3. Contemporary relevance

Table 5 presents three widely discussed McHargian projects and their implications to contemporary practice (McHarg & Steiner, 1998; Spirn, 2000; Yang et al., 2013). Plans for the Valleys and the Potomac River Basin study were conducted in Penn design studios, and The Woodlands plan by WMRT staff (mostly the Penn team). Many innovations by McHarg (WMRT) that were once seen

as radical are now common practice. The most noteworthy one is McHarg's landscape suitability assessment framework ("layer-cake" model) that spearheaded the development of the modern-era Geographic Information System (GIS) (Ndubisi, 2002, 2014). In fact, the computerized soil and vegetation surveys used in The Woodlands represented one of the first actual applications of GIS technology to a built project (McHarg & Steiner, 1998).

Likewise, the "natural" drainage channels in The Woodlands witness their contemporary applications, such as the rain gardens and stormwater planters commonly seen in the green streets in Portland, Seattle, Philadelphia, Kansas City, and other cities. An ongoing master-planned community development adjacent to The Woodlands, Springwoods Village (728 ha), followed several of the WMRT planning/design strategies (e.g., open drainage and forest preservation) (Jost, 2012). The U.S. Environmental Protection Agency (U.S. EPA)'s low-impact development and green infrastructure design initiatives further promote McHarg's design-with-nature ecological wisdom (Yang et al., 2015).

The Woodlands design team included Narendra Juneja, Jonathan Sutton, Mokun Lokhande, Anne Spirn, Colin Franklin, Leslie Sauer, and James Veltman. Anne Spirn went on to have a distinguished academic career and is currently a professor of landscape architecture and planning at MIT. Members from the WMRT team also founded two prominent professional firms. Colin Franklin and Leslie Sauer founded Andropogon Associates in 1974, and Robert Hanna and Laurie Olin founded Hanna/Olin in 1976 (now OLIN) (Spirn, 1985). Currently, both firms enjoy international reputations and have influential practices. Andropogon, in particular, uses "designing with nature" as the firm's credo, whose many projects feature creative stormwater management techniques (Yang et al., 2015).

Last, although McHarg applied his design process and analytic framework primarily in suburban and exurban settings (see Table 1), the process and framework can be extended to urban settings. McHarg's followers inherit his ecological wisdom and further contribute to urban/metropolitan sustainability (Bunster-Ossa, 2014; Hough, 1995; Spirn, 1984). Other scholars build on McHarg's environmental focus and strengthen social, economic, aesthetics, and public health dimensions of sustainability, while advancing theoretical frameworks and actionable agendas, such as Lyle's regenerative design (Lyle, 1999), Nassauer's "cues to care" (Nassauer, 1995; Nassauer, Wang, & Dayrell, 2009), Johnson and Hill's and Steiner's frameworks for ecology and design (Johnson & Hill, 2002; Steiner, 2008, 2011), Ndubisi's sustainable regionalism (Ndubisi, 2008), Musacchio's six *Es* for landscape sus-

tainability (Musacchio, 2009), Pliny Fisk's biophilic design (Kellert, Heerwagen, & Mador, 2011), and the Lady Bird Johnson Wildflower Center's Sustainable Sites Initiative (SITES) (Calkins, 2012; Steiner, Simmons, Gallagher, Ranganathan, & Robertson, 2013). Practitioners continue to apply McHarg's ecological wisdom to actionable agendas in order to tackle many sustainability issues around the world.

## 5. Conclusions

We conclude that McHarg's ecological wisdom is actionable, defensible, and meaningful, as evidenced in The Woodlands' outstanding landscape performance which is in accord with the benchmarks that McHarg (WMRT) forecasted. McHarg's ecological wisdom of designing with and dwelling in nature allows the performance of real and permanent good for the built environment. It is also important to note that the "secrete" of McHarg's ecological wisdom is anchored in his interdisciplinary training and practice, his love of Mother Nature, his creative blending of scientific theories with landscape planning and design, and his strong capacity to pervade the idea of design-with-nature to the general public.

Finally, the significance of The Woodlands design solution needs to be understood in its historical and site contexts. Its holistic solution is likely a one-of-a-kind plan that tackled wicked problems specific to this particular site. Therefore, this solution may not be directly replicated in another project due to the inherent differences in the design problem(s). Although the plan for The Woodlands is context dependent, a well-articulated, comprehensive design process would lead to the expression and execution of McHarg's ecological wisdom.

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