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The geographical dimensions of patent innovation: history, precedents, praxis, and pedagogy, in an expanded field of landscape technology.

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Abstract

Innovation has geographical dimensions, ranging from site and building technology, to infrastructure and environmental systems. As the allied professions of environmental design expand disciplinary scope beyond aesthetics into questions of territory, landscape infrastructure, performance-based design, and issues related to climate adaptation and the Anthropocene, an expanded concept of technology and innovation becomes essential to address new pedagogical adjectives and praxis. One of the most effective ways to track technological change in a specific sector of technology is through patent innovation. The global patent archive is the world's largest technological dossier. An estimated 90 million patents have been granted globally, and the United States Patent and Trademark Office (USPTO) alone has issued more than 10 million patents since 1790. A unique subset of these inventions relate to site and building technology as well as large-scale environmental systems such as rivers, coasts, and cities. Since patent innovation is an ongoing process, patent documents provide insights into the ever-evolving sectors of technology, which may be understood as an expanded field of landscape technologies that define site, cities, and regions. This paper explores the histories of patent innovation related to the physical built environment and argues for an expanded definition of "Landscape Technology". The paper also includes examples of New pedagogical approaches that integrate patent innovation studies into environmental design curriculum, and a discussion of strategies for implementing novel technologies and patent innovation studies into professional design projects.

Introduction - Geographical Dimensions of Patent Innovation

The geographical dimensions of patent innovation span six-centuries, and counting, with scales that range from discrete site technologies and building systems to urban and territorial infrastructure. An estimated 90 million patents have been granted globally, and the United States Patent and Trademark Office (USPTO) alone has issued more than 10 million patents since 1790. Individually each patent document describes the unique function and configuration of a specific technology, yet in aggregate the geographical dimensions of patent innovation portray a complex narrative of human ingenuity and invention environmental design dating back to early Venice. In 15th century Venice, patent rights were conceived as a legal tool to incentivize innovation manufacturing and industry, but also as a sociotechnical mechanism to advance the physical infrastructure essential to urbanize the lagoon and facilitate territorial development.

The coevolution of city-building and inventors rights suggest that a distinct urban innovation model was created, and later emulated, as patent rights spread from Venice to Europe and the United States to solve environmental "problems" through technological innovation.[i] Today numerous case studies exist, explicating the geographical dimensions of patent

innovation, ranging from the development of Mississippi River's levee and jetty systems, to the advent of complex coastal armoring systems (Fig.1). The parallel evolution of technology and the built environment not only substantiates the unique role of innovation in physical environment but also suggest a unique form of design agency relevant to design practice and pedagogy today as the allied professions of environmental design focus disciplinary agendas on issues related to performance, infrastructure, adaptation to climate change, and issues related to the Anthropocene – all of which suggest a shift towards an expanded field of technology.

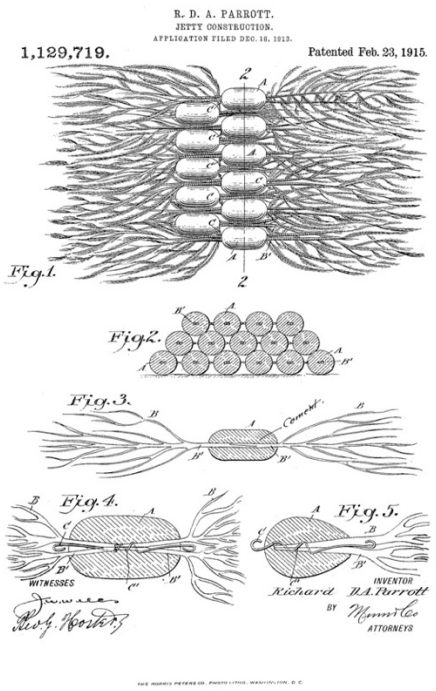

Fig. 1 A 'biomimetic' jetty patent from 1915 US129719. The patent describes the creation of pill shaped concrete blocks that anchor massive woven structures that mimic seaweeds or tree roots, with the intention of accreting sediments to stabilize the jetty and catalyze growth

Distinction between form and aesthetics has a clear legacy related to patents. The United States Patent and Trademark Office (USPTO) distinguishes between two major classifications of patents: design and utility. A design patent is issued for "a new, original, and ornamental design embodied in or applied to an article of manufacture, whereas a utility patent is issued by the USPTO for "the invention of a new and useful process, machine, manufacture, or composition of matter, or a new and useful improvement thereof." Simply put, design patents protect the form and appearance of everyday objects, while utility patents define innovative processes, materials, modules, systems, and infrastructures. A disciplinary shift towards instrumentality may make this distinction especially relevant to contemporary discourse.

Recent research in the field of architecture and technology has clearly identified the manifold ways in which intellectual property interacts with building systems, ranging from architectural components and systems, to copyright.[ii] Yet, when viewed through the lens of landscape and environment, a distinct subset of patents gain geographical dimension and situate technology with environmental contingencies. As we expand the disciplinary boundaries of environmental 'design' beyond aesthetics and appearance, and into broader discussions of instrumentality and agency in the Anthropocene, our conceptions of technology must coevolve. This makes patent innovation particularly relevant to contemporary discourse in the wider field of environmental design, including Landscape Architecture, where geographical scales and the dynamics of large-scale environmental systems are a primary consideration.

Venice and Patent Law – A geographical perspective

The first modern, or "true", patent is often attributed in the history of law to Filippo Brunelleschi, the eminent Florentine architect, in 1421 for a floating vessel to transport materials for his Duomo di Firenze.[iii] Although prescient, Brunelleschi's patent was an anomaly in Florence, where patent law failed to develop until later in Italian history. Brunelleschi's patent is significant as is contains all the components of the modern "patent bargain" between inventors and the state, and clearly indicates the intimate mirroring that often occurs between

invention and the built environment. It is striking to consider that the patent was so intricately intertwined with the realization of the Duomo of Florence, that the structure might not exist without the protections granted to Brunelleschi for his invention.

Brunelleschi's nascent foray into intellectual property was an anomaly, as Venice is widely considered the birth city of patent law.[iv] Precedents for inventor's rights and early patent law are documented in Venice since the early 14th and 15th century, primarily in the form of privileges and monopolies granted to inventors and manufacturers, but also for the development of public works such as the digging of canals and dredging exiting waterways. These rights and privileges later served as important precedents for patent law in the city. In this manner, innovation and urbanization became intimately intertwined in Venice prior to the formal codification of patent law in 1474, and continued as the city developed over the next few centuries.

Environmental and Urban innovation was essential to the survival of Venice. The city was founded in the estuarine landscape of the Leguna Venata on March 25th, 421 AD. Venice's watery refuge was defensible from invasion, but presented a challenge to conventional land-based forms of urbanism. Prospects of building a thriving metropolis in a dynamic lagoon environment required technological and social innovation to remain competitive in global trade and manufacturing, but also to reconcile the inherent conflict between city building and the environmental contingencies of sedimentation, fluctuating water levels, and miry soils. It was in this environmental and urban context that patent law was conceived. Inventor's rights, or privileges, granted in association with public works may seem antithetical today, yet many have forgotten the public and inherently sociotechnical and urban aspects of patents as they were first conceived. Contrary to contemporary notions of patents relating to items of manufacturing and trade, the early patents often had no immediate commodity associated with them and were conceived in terms of their public and geographical scope. Mario Biagioli, a leading scholar in law, science, and technology summarizes the issue as follows:

"It is striking how specific and local the early notion of utility was when compared to the increasingly generic definition we find in today's patent law. In the age of global economies utility seems to have no identifiable beneficiary beyond a generic 'public' situated in an equally unspecified future. By contrast, some of the earliest patents - like those related to the making and dredging of canals in Venice or the drying of swamps in the Netherlands - concerned public works, not privately-owned technological products to be sold on a generic market. Though not many patents were so site-specific, a distinctly local and immediate notion of utility informed all early privileges, especially those issued before 1700" [v]

Records of these early patents are striking for their distance from contemporary notions of a patent, but also for their emphasis on public and urban works. For Example, the Maggior Consiglio (The Major Council) issued an "award" to the inventors Leonardo Albizio and Franceso "dalle barche" in 1334 and 1346 respectively for their invention of time saving dredge vehicles, and allowed them to operate the machines in the city. And, similarly in 1371 Hendrigeto Maringon was hired for the clearing of canals using an excavator of his own invention, essentially granting him a monopoly for the machine he created and the geographical scope of work.[vi] Agreements, such as these, between inventors and city mangers served as important precedents for patent law in Venice, but also established a trajectory of experimentation and testing in urban infrastructure. The lagoon city literally and metaphorically created a fertile ground for innovation. The Venetian Patent Statute of 1474 was conceived as a public/private partnership designed to promote individual innovation and the

advance the state. Sociotechnical, public, and urban aspects of the law cannot be understated. The act reads:

"WE HAVE among us men of great genius, apt to invent and discover ingenious devices; and in view of the grandeur and virtue of our City, more such men come to us every day from diverse parts. Now, if provision were made for the works and devices discovered by such persons, so that others who may see them could not build them and take the inventor's honor away, more men would then apply their genius, would discover, and would build devices of great utility and benefit to our commonwealth."

Evolution of patent rights in Venice is intimately tied to geography. Venetians realized that building a thriving metropolis in a lagoon required legal, social, and technical ingenuity in both industry and infrastructure. It is therefore unsurprising that many archetypal patents have distinct geographical dimensions that site and situate innovation in Venice, both to attract inventors to Venice and deter foreign competition. For example, the rights issued to Ser Franciscus Petri on February 20th, 1416 for the manufacture of wool involved the use of a previously known type of Byzantine fulling device for the cleansing of wool. This agreement precluded use of the method by others within a 10-mile radius of Rialto (Venice) for a period of fifty years.[vii] Ser Franciscus Petri's patent was essentially a form of monopoly that prohibited production of similar products within a geographical radius of the city, but did not necessitate that an invention be new - only requiring that it be new to Venice and be operated within its territory. This not only applied to industry, but also to city building.

From the Canals of Venice to the Department of Interior

Patent law spread through Europe, to England, France, Germany, and the Netherlands after the Venetian Patent Statute on 1474. The historian Bruce Bugbee has even claimed "the international patent experience of nearly 500 years has merely brought amendments or improvements upon the solid core established in Renaissance Venice."[viii] The spread of patent law had urban, regional and territorial impacts that extended beyond the realm of manufacturing and industry, into what Henry Lefebvre terms the "urban society" – a political and technological system of total urbanization.[ix] In this milieu, where science, expertise, and the circulation of knowledge impacted cities, territories, and nations, the patent has played an important but surprisingly surreptitious role. A rereading of English and American patent history is particular telling. Originally English patents, like Venetian, were essentially a mix of monopolies for particular trades and enterprises and rights granted to protect new inventions. Patent monopolies became tools for the English monarchy and guilds to maintain power over goods and labor.

Queen Elizabeth herself granted nearly 80 patent monopolies for a range of goods and expertise, including the creation of white soap, saltpeper, knife handles, musical instruments, dredging machines, and important skills such as glass making, water drainage, and the mining of minerals. This lead to a influx of skilled workers and inventors, including those involved in the drainage, dredge, and reclamation technologies from Venice and the Netherlands. Interestingly, one fifth (1/5th) of all patents granted between 1620-1640 were for methods to raise water and drain land for reclamation, revealing the scope and scale of innovation in this sector of technology.[x] The fens and lowlands of England would never be the same as drainage infrastructure was constructed through a complex process of technology transfer from Italy and Holland using patents.

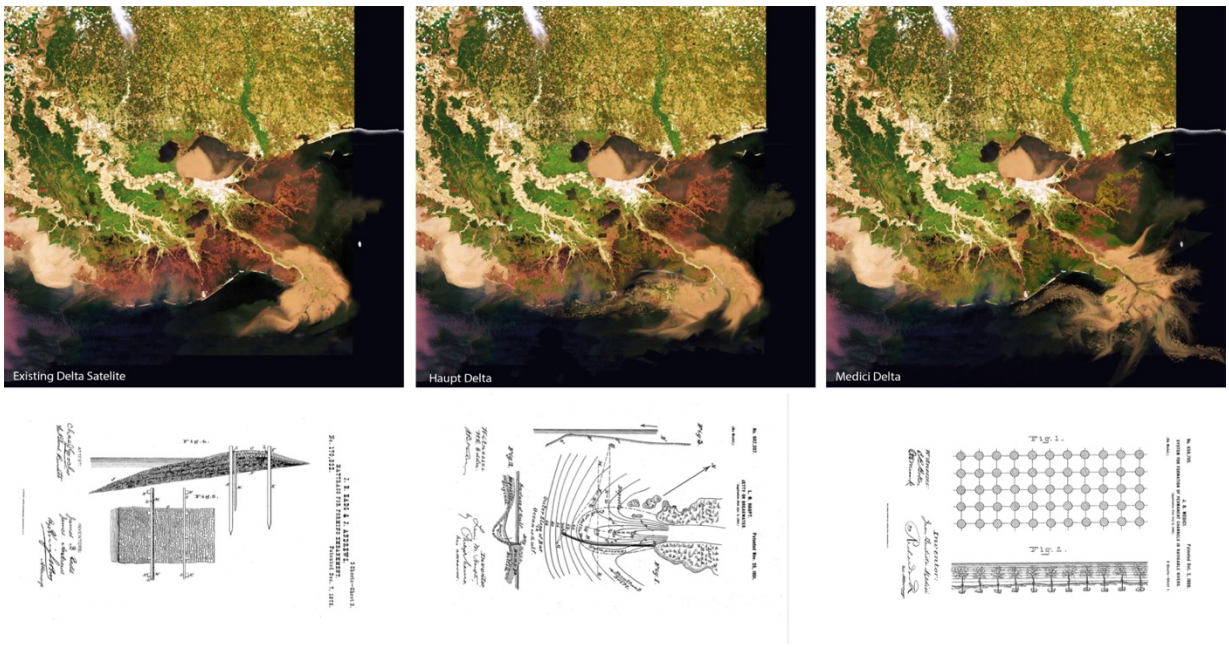

Fig. 2 Patent innovation impacts large-scale environmental systems, including rivers, coasts, and cities. The images above show a series of site-specific inventions patented for the creation of navigable channels at the Mississippi River, Heads of Passes. On the right is the existing satellite image, and the patent by James Buchannan Eads that stabilized the southwest pass of the river.

In America, patents are intimately intertwined with the nation's founding. Prior to the American Revolution colonial patents mirrored European, and specifically English, patent law.[xi] Establishment of a patent system was one of the first orders of business in the newly formed government, and the Patent Act of 1790 charted a distinctly American patent system founded exclusively on rights for new inventions and requiring that patents disclose enough information so that those skilled in any particular art might to make and use the technology.[xii]

The constitutional origins of American democratic ideals and their conflation with patent law provided a nascent US with a hybrid vigor through which statecraft became inexorably linked to progress and innovation. In this manner, western progress and technological frontiers advanced concurrently. The impact of which can be observed in the exponential growth of the American economy, and the geography of North American writ-large, from the barbwire fences of the middle-west to the reclamation of western swamplands.[xiii] Although it is common to associate American patents strictly with objects of commerce, it is important to note that from 1790 to 1849, the USPTO was operated by the Department of State with patents initially granted by the Secretary of State, Attorney General, Secretary of War, and for a brief time the President. The increasing rate of patent submissions and explosion of domestic affairs overwhelmed the State Department and led to the creation of the Department of Interior in 1849. Between 1849–1925 the patent office operated under the auspices of the Department of Interior, spanning an unprecedented period of national growth and development marked by canal building, railroads, electricity, sewers, paved roads, navigable waterways, and the first levee systems.

The Department of Interior was formed through a strategic reorganization of the USPTO, General Land Office, Census Bureau, and Bureau of Indian Affairs and charged with the management of "home" affairs,

including wilderness areas and new US territories. The combined interests of the Department of Interior made it the de facto "department of the west," playing a vital role in the expansion and development of western states. Although grand in ambition and scope, the actual footprint of the Department of Interior was remarkably small—initially housed within the patent office building in Washington DC. These two seemingly disparate offices cohabitated for six decades, until the constant flow of tourism to the building and the growing piles of patent models forced the Department of Interior to move out. Richard Andrews, an environmental policy scholar, has argued that in an ideal world, the integration of interior, patent, land, and census departments might have provided the "foundation for integrated planning and management of the nation's environment." [xiv] By 1925, the patent office found its permanent home in the US Department of Commerce, where it remains today.

Dusting off old patents from early American history reveals that the US government was cognizant of the role of patents in the transformation of the built environment. For example, in 1821 Congress waived the residency requirement to grant Englishman Thomas Oxley a patent for his "American Land Clearing Engine," which promised to hasten development. In 1844, while pondering interstate communications, Congress passed acts to construct an experimental telegraph line from Washington to Baltimore following Samuel Morse's patent for invention. And in 1847, James Crutchett was commissioned to prototype and test his experimental gaslight in the nation's Capitol, proving the viability of artificial lighting in the urban landscape.[xv]

The process of patent innovation, expert review, and prototyping technology in the built environment continued in large-scale complex environmental systems. For example in 1845, Congress approved the creation of a panel of experts to test an experimental dredge machine, patented by J.R. Putnam, for the removal of sandbars at the mouth of the Mississippi River.[xvi] And, in the 1870's the world-renowned engineer, James Buchanan Eads, himself had a patent to accompany his proposal for the establishment of navigable channels at the Heads of Passes.[xvii] Congress awarded Eads a contract for 4 years to prototype and test his system, and paid him based on success of the work.[xviii]

An Expanded Field of Landscape Technology: research trajectories and experimental pedagogies

The patent is western civilizations oldest legal and institutional mechanism for incentivized innovation, with a six-century history of facilitating the advent of complex infrastructure. It is often associated with commerce and objects of manufacturing, but, also with the transformation of large-scale and complex environmental systems. As we expand professional boundaries into the unknown realms of the Anthropocene, territorial design, socio-ecological innovation, a strategic reevaluation of patent rights may help advance disciplinary agendas beyond discrete site and building envelopes - offering a prelude to an expanded field of landscape technology.

Landscape technology operates at scales that range from site detail to larger territories and urban systems. The expanded field of landscape technology now arguably includes not only discrete design elements but also larger processes, methods, and machinery, that build infrastructure and armatures at environmental scales. This is substantiated through historiographies of site technologies and analysis of the broader urban and regional landscape chronicled in the patent archive.

An evolving dossier of historical case studies has now facilitated the creation of experimental pedagogies that integrate patent innovation into site and territorial design processes. Integration of patent innovation into pedagogy takes many forms, from heuristic models for problem solving and generative design process, to rigorous innovation studies that situate knowledge and prior art in a specific sector of technology. To illustrate these points

two pedagogical approaches will be discussed in this section. The first results from the LAEP Innovation Seminar (LDARCH 226) taught at UC Berkeley (2016-2019), focusing on the fabrication of hard habitats for coastal armoring. The second focuses on an experimental workshop for territorial design at the scale of the Sacramento- San Joaquin Delta in California. Both integrates patent innovation, images, and history in distinctly different ways, with different outcomes.

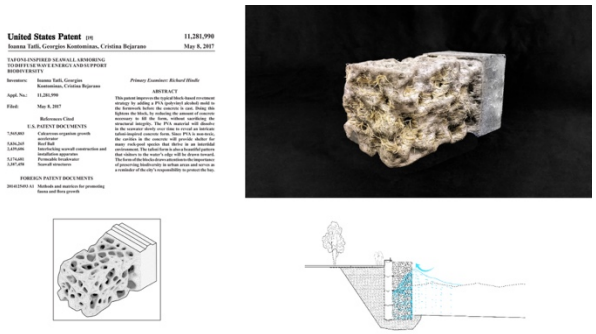

Fig. 3 Outcomes from the LAEP Innovation Seminar include functional prototypes, patent citation searches, mock patent documents, and site design drawings that show how the new "invention" impacts the built environment.

The L.A.E.P. Innovation Seminar (LDARCH 226) at UC Berkeley, explores the habitat potential of hard structures in the urbanized environment, focusing specifically on the design and fabrication of ecological seawalls and vegetated architecture. The course advances in the science, technology, and design of "hard habitats", and speculates about their potential future role in the novel ecology created by cities, buildings, and built environmental systems. The course title Hard Habitats also instigates a design polemic that inverts the notion of 'ecology' as soft and vulnerable, instead suggesting that organisms, and the habitats they seek, may be tough, resilient, and more forceful than a veneer of green or subtle ecological metaphors may suggest. Importantly, the course posits urban ecology as a distinct sector of technology, with the capacity for innovation.

An robust body of scientific research, pilot projects, and patents, support this premise and indicate that specific design criteria may improve the species richness and habitat potential of marine structures.[xix] This type of material and scientific experimentation is particularly well suited to design innovation within the field of landscape architecture given the field's hybridity, and evolving expertise in urbanism, ecology, and material expression.

The course begins with a comprehensive literature review, and then integrates patent innovation mapping techniques with speculate design processes including bricolage and experimental model making. The remaining weeks of the course advance a detailed design project focusing on the prototyping and fabrication new ecological seawall technology (Fig 3). Student projects are situated within a well-defined "innovation landscape" and each project evolves from an understanding of "prior art" existing in patent documents. The course integrates accepted innovation mapping techniques into design curriculum, including keyword searches and citation network searches. Students present their projects alongside existing patents and precedent projects, leading to a robust understanding of this sector of ecological technology.

In the summer of 2016, the author led a workshop, in collaboration with Neeraj Bhatia (CCA) as part of DredgeFest California that centered on sedimentation and earthworks in the California Delta. During the weeklong workshop, participants and workshop leaders were asked by the DredgeFest organizers to develop responses to a series of scenarios that covered the range of possible futures in the delta. Our team of designers were given the challenge of visualizing scenarios for the future earthworks of the delta. Instead of trying to unpack the full complexity of the California's Delta in such a short duration, we focused on the design of discrete

technologies (mock patents/inventions) and simulated their territorial effects as bottom-up acts of design speculation. This allowed us to begin iterative design experiments right away using a heuristic model based on patent innovations. And, as the workshop progressed, it enabled us to understand the relationship between a discrete technology and the broader region.

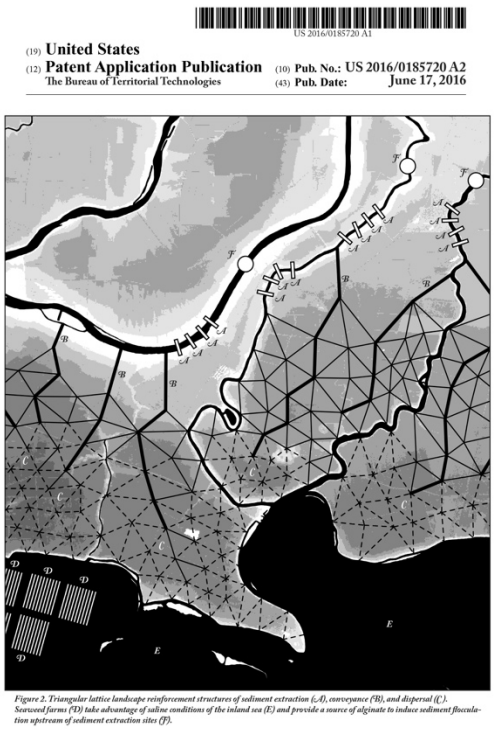

Fig. 4 Outcomes from the Dredgefest workshop (2016) included detailed designs for speculative technologies that impacted the broader regional landscape. Design agency was explored as a cross-scalar framework, operating simultaneously at the scale or the discrete object and the larger territory.

After a short initial exercise exploring existing technologies from the patent archive and extrapolating their territorial impact, four new technologies were "invented". Graphic standards were borrowed from patent documents and included details of how the system operated at the scale of the detail, to the scale of the region. Each addressed issues ranging from subsidence and accretion of sediment, to aquifer recharge and levee reinforcement. For example, the Regional Reinforcement system, created by Michael Biros, addressed the issue of sea level rise and land subsidence in low-lying areas. The object of the invention was to provide a method to convey and disperse sediment through easily deployable sluices that direct water into permeable seepage and dewatering structures (Fig 4).

By developing a specific technology and understanding how it would alter the broader the landscape, it allowed designers to quickly understand the implications of their design proposals, moving back and forth between technological invention, and regional transformation, ultimately facilitated design experimentation at the scale of the territory and at the detailed scale of a specific technology developed by the designer. The difference between these experiments and those of traditional site design and analysis, is the feedback between the micro and macro scale technology. Territorial effects could be explicitly directed and choreographed by acknowledging the cross-scalar relationship between various components. In essence, we posited that singular devices and technologies could effectively reconfigure a large-scale territory. In this sense the patent served as historical source, and projective framework, for future scenarios for the delta.

A Case Study in Landscape Architecture Professional Practice

In 2017 the Resilience By Design Bay Area Challenge was launched in California, with 9 international multidisciplinary teams selected to develop strategies for sea level rise and climate change adaptation. The Common Ground Team, lead by the Landscape Architecture firm Tom Leader Studio selected the San Pablo Baylands, and its adjacent infrastructure and urban fabric, as a site. The team included Tom Leader Studio, SF Exploratorium, Guy Nordenson & Assoc, Michael Maltzan Arch, HR&A Advisors, Sitelab Urban Studio, Lotus Water, Rana Creek, Dr. John Oliver, Richard Hindle, UC Berkeley, Fehr & Peers

Transportation Consultants. The diverse team approach the collaborative design process through charrettes, research, community meetings, stakeholder engagement, and envisioning processes, to develop a comprehensive strategic plan to be enacted over years and decades as climate change impacts the region.

Fig. 5 The project considers a new future for this highway as an elevated scenic byway, creating an iconic "front door" to a vast ecological open space previously known to few, The Grand Bayway will become a Central Park *with more 21st century sensibilities for rapidly expanding North Bay communities*

The site of San Pablo Baylands is among the largest wetland estuaries in California, located between Vallejo and Peteluma. The tidal bay marsh formed over centuries through the fluctuating waters and sediments of San Pablo bay and the freshwater inputs of Napa river and smaller creeks in the watershed. Today the bay edge marsh front is traversed by highway 37, a busy, yet extremely flood prone roadway linking the northern bay area to San Francisco. The design team developed a robust infrastructural plan for the area and roadway, including a new multifunctional elevated causeway.[xx]

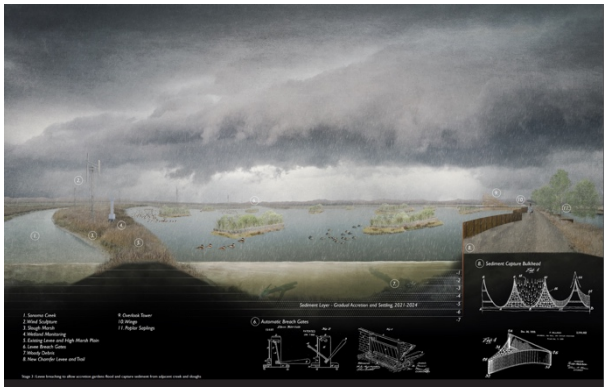

Fig. 6 Image of a flooded hyper-accretion garden structured using specialized technologies selected from patent sources.

A major component of the project was a restoration of the highly degraded, channelized, and subsided wetland now operating as agriculture bound by levees. Some areas of which have become open water though levee breeches, and others remain actively cultivated. Instead of providing a detailed plan for the 50,000-acre site, the contingencies and phasing of the site strategies were linked to specific site timelines and relevant technologies for accretion of sediment, benthic ecology, water regulation, and incremental adaptations to sea level rise. Each landscape condition was the linked to an innovation network of patented technologies that might be used to structure the site. In certain instances, specific site assemblies were suggested, and integrated into the design, showing how each technology would impact the site and future scenarios for the region. The team adapted existing technologies to the design framework, and then made informed suggestions for future needs based on these innovation studies. This led to novel site designs at detail and regional scales, while linking geographical contingencies to technology.

Conclusion

The geographical dimensions of patent innovation spans centuries and reveals the coevolution of technology and environment. Interpreting patent innovation through the lens of physical geography and urbanization has fruitful research and pedagogical potentiality, especially in the context of the Anthropocene as designers address complex environmental challenges. Integrating the geographical dimensions of patent innovation into research, provides a robust dossier through which to analyze the environment. For educators and students of landscape architecture the global patent archive chronicles and expanded field of landscape technology, helping to situate the discipline within a framework of innovation. This expanded field has yet unforeseen implications as we look towards the future of design desiccation and praxis. For example, in territorial design studios and seminars, a focus on innovation may help to frame technological questions related to site history and future transformation, by providing a high-fidelity window into physical infrastructure, mechanized processes, and material site assemblies. At the detail scale of site construction, patent studies can help explain a site's material complexity, or even develop narratives about the future of innovation required to reach a particular benchmark, such as ecological performance. This not only helps students and designers understand site processes, but also facilitates discourse and in-depth research through the lens of design and technology. Speculating on the future of professional practice, the geographical dimensions of patent innovation also suggests a new form of design agency rooted in historical precedent.

Notes:

[i] Richard L Hindle, "Inventing Venice: An Urban and Environmental Innovation Model from the Lagoon City," *J. Pat. & Trademark Off. Soc'y* 100 (2018): 529.
[ii] Decker, Martina, "Novelty and Ownership: Intellectual Property in Architecture and Design," *Technology|Architecture + Design* 1, no. 1 (n.d.): 41–47.
[iii] Frank D Prager, "Brunelleschi's Patent," *J. Pat. Off. Soc'y* 28 (1946): 109–109.
[iv] Giulio Mandich, "Venetian Origins of Inventors' Rights," *J. Pat. Off. Soc'y* 42 (1960): 378.
[v] Mario Biagioli, "From Print to Patents: Living on Instruments in Early Modern Europe," *History of Science* 44, no. 2 (2006): 153.
[vi] Roberto Berveglieri, *Le Vie Di Venezia: Canali Lagunari e Rii a Venezia: Inventori, Brevetti, Tecnologia e Legislazione Nei Secoli XIII-XVIII* (Cierre, 1999).
[vii] Giulio Mandich, "Venetian Patents (1450-1550)," *J. Pat. Off. Soc'y* 30 (1948): 166.
[viii] Bruce Willis. Bugbee, *Genesis of American Patent and Copyright Law,* (Washington: Public Affairs Press, 1967).
[ix] Henri Lefebvre and Robert Bononno, *The Urban Revolution* (Minneapolis,MN: University of Minnesota, 2003).
[x] W.H. Price, *The English Patents of Monopoly*, Harvard Economic Studies (Harvard University Press, 1906), https://books.google.com/books?id=WNw9AQAAMAAJ.
[xi] P J Federico, "Colonial Monopolies and Patents," *J. Pat. Off. Soc'y* 11 (1929): 358–358.
[xii] Craig Allen Nard and Andrew P Morriss, "Constitutionalizing Patents: From Venice to Philadelphia," *Review of Law and Economics* 2, no. 2 (2006): 223–321.
[xiii] Richard Hindle, "Levees That Might Have Been," *May 2015*, 2015, https://placesjournal.org/article/levees-that-might-have-been/.
[xiv] R N L Andrews, *Managing the Environment, Managing Ourselves: A History of American Environmental Policy* (Yale University Press, 1999), https://books.google.com/books?id=yxzcMhK9HdYC.
[xv] J B Miller, *Principles of Public and Private Infrastructure Delivery*, Infrastructure Systems: Delivery and Finance (Springer US, 2013), https://books.google.com/books?id=dIjSBwAAQBAJ.
[xvi] James R Putnam, *J.R. Putnam's Plan for Removing Bars at the Mouth of the Mississippi River and Other Harbors on the American Coast and Interior. With a Full Description of His Patent Ploughing and Dredging Machine, Invented by Him for That Purpose, with Drawings, Etc.* (New Orleans: Printed at the Bulletin Office, 1841).
[xvii] Richard Hindle, "Prototyping the Mississippi Delta: Patents, Alternative Futures, and the Design of Complex Environmental Systems," *Journal of Landscape Architecture* 12, no. 02 (n.d.): 32–47, https://doi.org/10.1080/18626033.2017.1361084.
[xviii] Martin Reuss, "Andrew A. Humphreys and the Development of Hydraulic Engineering: Politics and Technology in the Army Corps of Engineers, 1850-1950," *Technology and Culture* 26, no. 1 (January 1985): 1-33 CR-Copyright © 1985 Society for the H, https://doi.org/10.2307/3104527.
[xix] R Hindle, "The Hard Habitats of Coastal Armoring," 2018. In: Sustainable Coastal Design and Planning
[xx] "The Grand Bayway (North Bay) — Bay Area: Resilient By Design Challenge," accessed April 4, 2019, http://www.resilientbayarea.org/grand-bayway.