# Urban Brownfields Redevelopment via Industrial Hemp for Future Development of Urban Green Spaces and Gardens, and Hemp's Potential Future in Pennsylvania

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While it is universally known in sustainability that urban areas lack access to healthy, local food, and green space, few people outside the field seem to know amelioration tactics. Brownfields redevelopment has long been accepted as a means of urban restoration, but it hardly seems to hold true to a scientific dogma. “Gary”, Executive Director of an urban farm non-profit in Pennsylvania, claims to have spent several years adding organic material to his vacant lots and eventually brining in his own topsoil (personal communication, February 18, 2015). Though this method worked, and “Gary’s” farm has flourished immensely, it does not seem to have been the most efficient means of conditioning a dilapidated and contaminated soil plot for vegetative growth. Industrial hemp, which is on the verge of legalization in the state of Pennsylvania,[1] has the proven ability to not only withstand contaminated soils, but accumulate the toxins within.[2] Such poor soil qualities are characteristic of brownfields, defined as “real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.”[3] Vacant lots in urban areas are all potential brownfield sites, which may be phytoremediated via industrial hemp by a state Voluntary Cleanup Program (VCP) for future development of green spaces or community gardens. A main struggle for starting urban farming businesses seems to be fertile, healthy soil- the state of the ground’s health and its requirements for revitalization discourage one’s initiative for garden growth. Brownfield development in conjunction with industrial hemp will eliminate the first step for urban gardeners’ careers. Proposed here is a phase-oriented restorative research framework on using higher education institutes to do research on hemp as a phytoremediator on urban brownfields, which will facilitate creation of green spaces and urban gardens for local communities.

Brownfields redevelopment is a trademark of sustainable land use due to the economic and societal benefits of restoring an underused urban parcel being greater than

similar development on greenfields.[4] Goals of the smart-growth movement mesh well with those of brownfield redevelopment. Successful restoration of urban land includes integrated decision making, public involvement, and measureable outcomes for sustainability embodied in program designs.[5] A challenge of brownfields redevelopment is the enormity of such a task- a 2004 report by the National Association of Local Government Environmental Professionals (NALGEP) and the Northeast-Midwest Institute (NEMW) predicts that there could be as many as one million brownfield sites nationwide.[6] A main component of brownfields redevelopment is smart-growth, which refers to the "the myriad 'creative strategies to develop in ways that preserve natural land and critical environmental areas, protect water and air quality, and reuse already-developed land'".[7] Pennsylvania has over a decade of experience in brownfields remediation,[8] and was consequently founded on hemp.[9]

According to Hemp Basics ®, a manufacturer and distributor of hemp products since 1991 based in Warren, New Jersey, one acre of hemp has the ability to produce as much fiber as two to three acres of cotton. Little to no pesticides are used for hemp as well, and a single acre of hemp can produce as much paper as two to four acres of trees; hemp paper is also sturdier than tree paper, can be recycled more frequently, and requires fewer chemical inputs in manufacture. Harvest only comes after about 120 days.[10] The plant's intricate properties contribute to its four basic uses: food, fiber, fuel, and medicine.[11]

Fibers from hemp are extensively used in products including, but not limited, to fabrics and textiles, spun fibers (rope, yarn), paper, carpeting, home furnishings, construction and insulation materials, composites, and auto parts.[12] Hurds, short and woody fibers in hemp's stalk interior,[13] are used for animal bedding, papermaking, composites and material inputs. Hemp seed and oilcake are useful in various foods and beverages, while having value as an alternative protein source. Oil from hemp seed is found widely in body-care items and

nutritional supplements; the seed is also utilized as industrial oils, cosmetics, and pharmaceuticals. The global market for hemp may include more than 25,000 products in the nine submarkets: agriculture, recycling, automotive, textiles, food items, paper, construction materials, furniture, and personal care.[14] A commonly overseen use for hemp, especially before the plant gets to manufacturing operations, is its usefulness in phytoremediation of contaminated soil.

Overall, hemp plants are exceptional against heavy metals in soils, as shown by a study conducted in China. Eighteen cultivars of hemp were tested for tolerance and accumulation of cadmium (Cd) contaminated soils, screened for its potential bioenergy production in Cd-rich soils, and identified for its phytoremedial use.[15] Pot tests we done in a greenhouse of Huaibei Normal University in Huaibei, China. Soils were treated with Cd at 25 mg/kg, with separate control pots containing no Cd.[16] After 45 days, the seedlings were harvested and conditioned for analysis. Measurements for tolerance was expressed in percent as "Tolerance Index" (TI). Translocation factor (TF) and bioconcentration factor (BCF) were measurements for total Cd in shoots from roots, and total Cd in shoot and/or root compared to soil Cd, respectively, also expressed as percentage.[17]

The following measurements, with equations, were used for evaluation of plant growth and accumulation of metal: Tolerance Index (TI) was expressed for root and shoot biomass as $TI=100x[biomass]_{Cd}/[biomass]_{control}$, Translocation factor (TF) as $TF=[Cd]_{shoot}/[Cd]_{root}$, and bioconcentration factor as $BCF=[Cd]_{shoot\ or\ root}/[Cd]_{soil}$.[18] TI ranged as high as 93% for shoots and 89% for roots.[19] Cd content in shoots ranged from 11.4-24.9 ppm, but was significantly higher in roots, ranging from 217-481 ppm. Such was emphasized by a considerably low TF of 3.15-12.70.[20] Chlorophyll concentration decreased only slightly, with a few cultivars having statistically insignificant change, indicating photosynthetic potential

under high stress.[21] Results showed that all but three of the studied cultivars were considered to be good biodiesel crop candidates for phytoremediation in Cd contaminated soils.[22] Research associates in Pakistan contributed further to deepen the knowledge pool research on hemp's phytoremedial potential cadmium plus four other heavy metals.

Ahmed et. al. claim that hemp makes a premium candidate for phytoremediation due to high biomass, long roots and a short life cycle.[23] Hemp also has a high capability to absorb and accumulate heavy metals (HMs) lead (Pb), nickel (Ni), cadmium (Cd), zinc (Zn), and chromium. Underlying their main research goal was to identify and define GSR and PLDa genes from hemp plants, as the genome has yet to be sequenced and the responsible genes for stress tolerance of HMs are unknown; identification of the two genes could allow deduction of molecular pathways involved metals tolerance and uptake in hemp.[24] Cited in the document was the Chernobyl nuclear waste disaster, which, prior to the Pakistani experiment, provided the perfect opportunity for hemp phytoremediation.[25]

Hemp was planted in the contaminated soils of the Chernobyl disaster site in the Ukraine, and it was revealed that the plant can take up considerable amounts of HMs from contaminated soil thanks to high biomass and deep roots.[26] Researchers in Pakistan discovered a higher accumulation of Cu, Cd, and Ni, at 1520 mg/kg, 151 mg/kg, and 123 mg/kg, respectively.[27] Also cited in the document were a myriad of related studies, reporting accumulation of the former three elements, as well as Pb, Zn and chromium (Cr), which makes hemp suitable for soil remediation.[28] Other studies have found that HM accumulation increases with growing concentrations of HMs in the soil.[29] Another reported study elected hemp as the best bioaccumulator of Cd out of eight potential energy crops.[30] Heavily suggested is the notion that hemp is able to avoid cellular damage by activating different molecular mechanisms, the antioxidant system in particular.[31] It is concluded that hemp is a

great potential candidate to remove heavy metals from the soil, notably Cu, Cd, and Ni.[32] In the future, the brownfields redevelopment industry may want to consider phytoremedial hemp as the starting tool for urban improvement, but progress does not stop here.

Hemp phytoremediation is a new potential first step in the process of brownfields redevelopment. Once the soil is detoxified, and the hemp is cleared, implementation of cover crops must ensue to nurture the soil. State voluntary cleanup programs (VCPs) and volunteers of the surrounding community must band together for the formation of green spaces. In a perfect world, the green space will either remain in place indefinitely, or be transformed into a garden for local food if a willing and qualified gardener shows interest. However, zoning laws will render transformation of a public botanical refuge to a food garden to be a cantankerous endeavor. It would be best to determine into what the brownfield will be converted during the project's infancy. The EPA offers grants for tasks to make green-space creation possible.[33] Regardless of whether a redeveloped parcel of urban land is rebirthed into green sanctuary in the concrete jungle, or becomes transformed into the community's supply of local food, there is a broad acknowlegement that a good environment can enhance quality of life while advancing economic competitiveness.[34] Despite a high possibility of success with this measure, barriers are present.

As of the beginning of the year 2016, Pennsylvania is on the verge of legalizing industrial hemp. (Author's note: this statement is subject to change). Section 3, Article B of Senate Bill No. 50 used to state that the department under its agricultural pilot program, or an institution of higher education within the Commonwealth of Pennsylvania, holding a permit, may cultivate industrial hemp for the purpose of research, including marketing studies.[35] House Bill No. 967 also elaborated in Chapter 7, Section 704, Article b, stating "Industrial hemp shall be grown or cultivated in a manner that complies with the following: (1) Ensures that only institutions of higher education and the department be used to grow or cultivate

industrial hemp and (2) Requires that sites used for growing or cultivating industrial hemp be certified and permitted by and registered with the department.[36] Fortunately, both bills have been amended to allow one to form a contract with the PA department of agriculture without requirement of being in conjunction with an institute of higher education. An individual's growth of industrial hemp would be for one to help implement the Pennsylvania Department of Agriculture's pilot program.[37] Despite individual freedom, regulations are still present, and they are due in part to Congress's Controlled Substances Act of 1970 (CSA), which renders the states' abilities of hemp growth to be far from perfect.

Congress's CSA does not strictly make hemp growth illegal, but it implements harsh controls on its production.[38] It also uses outdated language, citing *Cannabis sativa* as "marijuana", both in the low and high THC varieties, placing public stigma that hemp and marijuana are the same plant.[39] Congress left responsibility of *Cannabis sativa* in the hands of the Drug Enforcement Administration (DEA). For hemp to be grown in the United States, one must acquire a DEA permit to grow the plant, and only for research.[40] Renee Johnson of the CRS argues that even if the DEA were to grant a permit, production could be limited or discouraged due to potential difficulties of collaboration with the DEA for licensing requirements and necessary structural installation to obtain a permit.[41] One must demonstrate that effective security be placed at the production site, including fencing, monitoring system, armed guards, and controlled access. Application requirements are a nonrefundable fee, FBI background checks, and a plethora of documentation also take place. Such tactics and requirements fiercely limit a facility's profitability, therefore rendering hemp growth nearly impossible.[42] Pennsylvania has managed to find the solution to partial legalization, but with just research and market studies allowed, commercial hemp is halted until federal intervention. Hemp phytoremediation will require city-college collaboration, non-profits partnerships, more work than expected, and possibly some hoop-jumping.

If only research is permitted, then commercial growth will not be able to take place. Hemp variety field trials and treatment studies of the plant will provide adequate study data for local and statewide growth, but no freedom would exist for the average farmer to cultivate the revitalized crop. Research will only be effective, and able to generate subsequent profit, if farmers of the state could use the very product of study. Such a case could make one wonder if Pennsylvania's state government will only be able to allow research considering the hemp's safety or physiology upon legalization. Tight restrictions may also place hemp in a negative public light; in essence, when one studies corn or soybean varieties, signs are displayed, indicating what is under scrutiny.[43] One may fear that when the renewed hemp crop comes into place, high electric fences plastered with yellow and red warning signs will display, informing the reader on how much trouble will ensue if they were to even touch the plants. A sustainable crop should not arrive with a surrounding aura of risk and danger. If the Federal government would release its hold on Cannabis of every type, and allow hemp to be grown nationwide and commercially, this would not be the case. Congress needs to take action to differentiate between hemp and marijuana; the Controlled Substances Act created a false and reductionist vernacular about the cannabis plant. If Pennsylvania, or any state, is to make money, create jobs, and grow an industry, then the federal government of the United States must relinquish its chokehold on hemp.

Conversion of tight DEA regulations in conjunction with the CSA are currently out of reach for most states, including Pennsylvania. While the Keystone State may not be able to easily sell its grown product, it could strategize for phase-oriented restorative research- an additive modification of John C. Dernbach's claim for mixed-use and smart growth development. If research may only be done through higher education institutions or agricultural pilot programs, then collaborative strategies should take place. Partnerships, and intricate teamwork between parties are essential.

Higher education institutions should form partnerships with one or more non-profit organizations concerned with brownfield redevelopment and green space creation. Working within city and state political bodies and respective laws, schools and non-profits must then acquire and rezone city parcels to conduct phytoremedial research, with the school possessing the ulterior motive of institutionally withdrawing from the process after research completion. Conjoining and involved non-profits and the city government will then have dictation over the urban parcel for completion of the phase-oriented restorative research. Hemp has already proven itself to effectively pull contaminants out of the ground, so further study can be done by higher education institutions to identify the best cultivars for the task in areas with redevelopment needs. Urban phytoremedial research on brownfields would likely be possible only for colleges within the vicinity of a city. Usage of urban land by higher education institutions could be feasible since cities, governments, and the institutions within often have existing relationships. With nearby schools taking interest in both academia and community outreach, local government must also act as a major role- player.

With the rise in urban population, cities must take initiatives to secure future quality of life and food supply with a focus on low income communities, as hierarchal oppression never disappears. Gardens, whether used for green space or food, are important for mental and psychological health for those who live in close proximity.[44] Sprawling land-use patterns and fragmented governance inhibit localities' abilities for smart-growth strategies and phase-oriented restorative research. Local and city governments must bring together the three tenants of sustainability into decision-making processes by necessity for future healthy food supply and physiological justice for urbanites.[45] The Mayors Climate Protection Act (MCPA), endorsed by the U.S. Conference of Mayors, is in support of reducing sprawl, promoting transportation alternatives, supporting green buildings, and cutting city power use[46]; Reason behind this event in June of 2005 was the view upon U.S. mayors that the

federal government was failing to enact on climate change and conservation.[47] Urban gardens fall under the MCPA by ameliorating a city's dependence on imported food and condensing the spread of food sources. An inquiry one may have is how Pennsylvania's hemp industry will benefit.

Urban soil phytoremediation will help the hemp industry get its restart in the two following manners: First, the plant will be advertised in densely populated areas for both its remedial qualities, and its use as starter tool for city improvement. Second, because of the potentially minuscule amount of profit made off of collaborative city-college research projects, Pennsylvania hemp will develop a philanthropic reputation against the pre-existing backdrop of an industrialized society which lauds wealth and materials. Once industrial hemp gets legalized for domestic commercial growth, mercantilism, and manufacture, the public would likely have the desire to support the hemp industry by buying their products. People will learn about the plant's product potential with its dozens of uses, and they will cry out for commercial growth. Urban phytoremedial hemp will not be feasible for profit, but grown in multiple-acre fields, the resource will be a highly viable market in coming years.

To conclude, industrial hemp has a long, rigorous path ahead, and higher education institutions, state and city governments, local communities, non-profits, and Pennsylvania's hemp industry must collaborate to foster a needed renaissance of urban life. Multidisciplinary approaches must be made, and the state must think critically in its implementation of this revitalized crop to avoid corruption and scandal. End products of industrial hemp will exceed the expertise of every party involved; risks must be taken, money must be spent, and the public must be educated. Life, liberty, and the pursuit of happiness is the United States' founding principle; if the government exists to protect the peoples' three basic rights, it must also implement economy, environment, and social justice. Physical health brings about life and happiness, so when the tools and resources exist to fix the lack of urban residents'

accessibility for life and happiness, but the government fails to enact, then two entities occur: 1.) The government has failed its people, and 2.) Responsibility has been placed on smaller political bodies at the origins and sinks of injustice to help bring about a new era of equality.

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