the landscape in 2025

Alternative future landscape scenarios: A means to consider agricultural policy

Agricultural policy implies new future scenarios for agricultural landscapes each time a new federal farm bill or emergency aid to farmers is debated. Future landscape scenario studies can suggest policies that could achieve specific goals or make the implications of proposed policy apparent. This paper compares the 1994 landscape with three alternative future landscape scenarios for two Iowa Corn Belt agricultural watersheds. Each alternative emphasizes different ecological, hydrological, and crop production goals.

People find it difficult to imagine a future that is very different from the present, but nearly any series of U.S. Department of Agriculture aerial photos taken over the past 50 years in the Corn Belt shows dramatic landscape change. Farmsteads, pastures and woodlots disappear, and cultivated fields grow to a size that would have been unimaginable in 1950. It is usually only in retrospect that people can see how much things can change.

To look 25 years into the future and imagine how Corn Belt landscapes could change, allows us to critically evaluate the potential consequences of the surprising character of the future. In this project, we used future landscape scenario studies to imagine how different policy choices could influence alternative futures for Corn Belt landscapes in 2025. Three alternative futures are compared with a 1994 base landscape for their potential effects on ecological functions, hydrological functions, economic return, and public acceptance of the alternative landscapes.[i]

Study areas

In an iterative interdisciplinary GIS-based process[ii], we developed three alternative scenarios for Corn Belt agricultural landscapes in the year 2025, and mapped them for two second-order watersheds that exemplify different soil and relief conditions in Iowa. Buck Creek watershed in Poweshiek County (8,790 ha; 21,700 acres) is a highly dissected landscape of loess-derived, relatively erosive soils (figure 1). In 1994, 29 percent of its area was in pasture or woodland and 16 percent was in the Conservation Reserve Program (CRP) (Freemark and Smith, 1995). Walnut Creek watershed in Story and Boone Counties (5,600 ha; 13,800 acres) is a relatively flat watershed of prairie pothole topography (figure 1). In 1994, 83 percent of its area was in corn

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and soybeans, and 1 percent was in CRP (Freemark and Smith, 1995). To represent Corn Belt agricultural watersheds, we assumed future population growth in both watersheds to be typical of rural Iowa, which will suffer population loss under current trends (Goudy and Burke, 1994).

Different choices: scenarios for Corn Belt agricultural watersheds

Each scenario assumes different leading goals for federal agricultural policy. All of the scenarios assume that agricultural and environmental policy reflects public perceptions, values, and concerns, and all assume that policy supports profitable agricultural operations by private landowners in 2025. Scenario I assumes that increasing agricultural production is the leading emphasis of policy. Scenario II assumes that improving water quality is the leading emphasis (figure 4). Scenario III assumes that improving biodiversity in agricultural landscapes is the leading emphasis (figure 5). We applied landscape ecology principles to design future landscapes for each scenario (e.g., Forman, 1995). Policy goals and implementation strategies, characteristics of each scenario, and their expected effects on ecological, economic, and social functions of the landscape are described. These functions were measured or modeled in related parts of our project (Santelmann, et al. 2001; Coiner et al., 2001; Vache et al., in press).

We designed the scenarios to be a provocative but plausible basis for imagining future directions for federal agricultural policy. While none is a prescription, each draws out some of the implications of different potential policy emphases. The scenarios in no way define a range of choices for agricultural policy. Rather they are intended to provoke consideration of some consequences of choices that could be made.

Base landscape: 1994 landcover

The base condition against which the three 2025 scenarios are compared is the 1994 Corn Belt landscape. Agricultural policy goals that affected that landscape included income support to farmers based on area of base crops, incentives for soil and water conservation BMPs, and incentives for voluntary ten year set-aside of highly erodible fields in the CRP, which also created habitat. Agricultural production required high use of fossil fuels and high use of chemical and technological inputs (Cochrane and Runge, 1992). While the public voiced concerns for food safety and the health of agricultural landscapes, the value of rural places was widely recognized (Northwest Area Foundation, 1995; Lockeretz, 1997). The number of farms in Iowa had dropped by 41 percent to just 91,000 from 1964 to 1997. Average Iowa farm size had increased from 219 acres to 343 acres over the same period (USDA National Agricultural Statistics Service, 1999). Small towns were being depopulated with resulting losses in small town businesses and civic institutions.

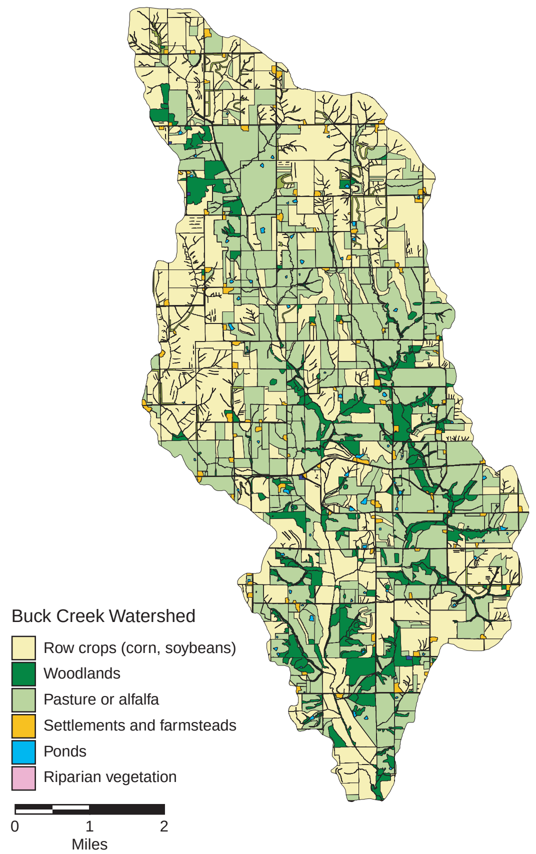
Scenario I: Increasing agricultural production

Scenario I increases agricultural production. Policy encourages cultivation of all highly productive land with the use of conventional technology and inputs. Water quality and biodiversity are protected using practices exemplified by the 1996 Federal Agriculture Improvement and Reform (FAIR) Act (Public Law 104-127 [H.R. 2854] April 04, 1996). Agriculture uses fossil fuels, chemicals, and technology to a degree that is similar to the present, and fossil fuels remain available. In 2025, agricultural operations and technology have continued to increase in scale, favoring the success of larger farms. The public supports large-scale, high-input agriculture, and trusts the safety and quality of food produced. The public perceives Scenario I landscapes to be environmentally acceptable.

Field patterns and livestock enterprises. To map this scenario, we identified land feasible for cultivation by using soil Corn Suitability Ratings (CSR) (Iowa State University, 1996), which assume artificial drainage of wet soils and adequate management (i.e., chemical and technological inputs). Any area of at least 3 acres (1.2 ha) of high CSR (greater than 65 in Walnut Creek, or greater than 50 in Buck Creek) that is accessible by combine is cultivated and planted to a corn soybean rotation, including land that was wooded in 1994.

> "There is ample evidence of the surprising character of the future." – I. J. Schoonenboom, 1995

Field size is limited only by steep slopes, public roads, and maximum combine loads. Combine hoppers are assumed to travel up to one-half mile (0.8 km) before unloading on mown lanes, which bisect 640 acre (260 ha) sections. In flat, high CSR watersheds like Walnut Creek, the landscape is dominated by fields up to 0.8 km (0.5 mile) wide, 320 acres (130 ha) of corn or soybeans, in a continuous rotation. Only fields larger than 30 acres (12 ha) of low CSR are planted to hay for sale. Within the fields, precision agriculture is adopted, and less productive areas as small as 30 feet (9 m) wide (one combine header width) or as large as 30 acres (12 ha) are simply mown annually and sprayed for weeds.(Stafford, 1996; Batchelor et al., 1997; Stombaugh and Shearer, 2000). Livestock are raised in concentrated animal feeding operations (CAFOs) in a few areas of the state outside the study area watersheds. This assumption is supported by current trends in siting CAFOs, in Iowa clustered in a few counties (Jackson et al., 2000).



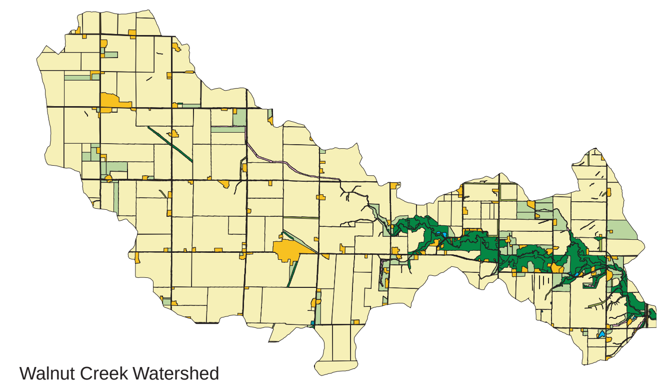


Figure 1 Buck Creek watershed (left) and Walnut Creek watershed (above) landcover (ca. 1994).

Conservation practices. Conservation practices that do not require taking even small areas of land out of production are favored. Twenty-foot (6 m) buffers of non-native perennial herbaceous species occur on both sides of streams. Conservation tillage and precision agriculture are applied comprehensively, but practices like oat rotations or strip-cropping are avoided. No reserve or set-aside programs are used.

Farmsteads, towns, and cultural practices. Farm size has nearly doubled since 1994 to an average of 640 acres (260 ha). Half of the farmsteads occupied in 1994 have been abandoned, and the land is now cultivated. Farmsteads that remain look prosperous and well-kept on large lawns. Roadsides are mown regularly and sprayed for weeds. Access to the rural landscape by the broader public is not encouraged. Few non-farmers live on former farmsteads.

Expected effects: Landscape network. Native species biodiversity is limited to woodlands remaining on the least productive soils. Narrow non-native herbaceous buffers along the streams, mown lawns and roadsides, and dramatically diminished woodlands constitute the only perennial cover remaining in 2025. Continuous buffers along streams help to establish riparian corridors, but their narrowness limits their habitat potential (Henry et al., 1999). There are no hedgerows or fencerows that could augment the stream buffer network.

Expected effects: Landscape grain. Large fields of corn or soybeans dominate the landscape and create a coarse-grained agricultural landscape with large gaps between habitat areas, which limits the movement of indigenous flora and fauna across the landscape (Henry et al., 1999).

Expected effects: Water quality and quantity. Conservation tillage and precision farming are adopted wherever possible, and this is expected to improve water quality (Batte, 2000; Forster et al., 2000). However, woodlands are reduced, the CRP is no longer in effect, and more land near streams is under cultivation since 1994, and this could reduce water quality (Castillo et al., 2000; Forster, 2000). The efficient tile drainage systems that enabled so much of the Corn Belt to be cultivated continue to deliver nutrients, herbicides, and pesticides to local streams at a relatively high rate. Stream flows are likely to remain flashy, with resulting sedimentation and flooding.

Expected effects: Agricultural production. Because the amount of land cultivated for corn and soybeans increases from 1994, direct market returns are likely to be higher under Scenario I, if 1994 prices continue.

Expected effects: Public acceptance. Scenario I is likely to be accepted by farmers because it increases grain production with related assumed increases in economic returns. However, Scenario I may contradict farmers' values for stewardship, personal health, and community prosperity (Kraft and Penberthy, 2000; Napier et al., 2000; Prato and Hajkowicz, 2001). The general public is likely to perceive the landscape as less attractive than in the past (Nassauer, 1988; 1989).

Scenario II: Improving water quality and flow regimes

Under Scenario II (figure 4), federal policy establishes performance standards to achieve improved water quality and flow regimes, and it supports agricultural enterprises that help meet those standards, including rotational grazing enterprises. Both the management requirements of rotational grazing and the rural tourism invited by pastoral landscapes create an economic base for more farmers to stay on the land compared with Scenarios I or III. Conventional BMPs (minimum tillage, rotations, strip cropping, continuous cover, and animal agriculture) are employed. Rotational grazing pastures and forage crops are located in fields adjacent to fenced stream buffers to protect water quality. Wider stream buffers of native vegetation and new, innovative BMPs detain and clean stormwater.

Field patterns and livestock enterprises. Livestock production with rotational grazing predominates on rolling land that is vulnerable to erosion, as measured by soil Land Capability Class (LCC). As a measure of soil productivity, LCC does not assume the management inputs assumed by Corn Suitability Ratings, but rather is a measure of suitability for cultivation and may reflect management inputs appropriate to rotational grazing enterprises. Management of rotational grazing is assumed to be optimal to protect water quality (Lyons et al., 2000; Stout et al., 2000), livestock are fenced out of streams (Belsky et al., 1999), and forage crops are planted in blocks of at least 10 acres (4 ha) adjacent to all perennial streams on all soil types.

Cultivated fields have at least 75 percent highly productive cropland (LCC 1, 2, or 3). Areas larger than 40 acres (16 ha) that are not highly productive are managed as separate parcels for rotational grazing or hay. In flatter areas with highly productive soils, fields are as large as 320 acres (130 ha), and planted in a corn-soybean-alfalfa-alfalfa rotation (Waide and Hatfield, 1995) implemented with no-till, BMP's, and precision agriculture. As in Scenario I, any area of at least 3 acres (1.2 ha) of highly productive land accessible by combine is cultivated.

Conservation practices. No land is taken out of production as a reserve or set-aside. Woodlands are retained for carefully-managed grazing rather than being converted to cultivation. Compared with Scenario I, Scenario II has more native vegetation; BMP's and precision agriculture patches are planted with perennial herbaceous natives. These small patches are mown only annually in late summer, and provide some habitat (Fahrig and Merriam, 1985; Basore et al., 1986; Freemark and Merriam, 1986; Best et al., 1995).

To improve water quality and quantity, new practices are implemented.

- In fields with slopes over 10% adjacent to streams, a 3 meter (10 foot) filter strip of native herbaceous cover is located about halfway up the slope.
- Small ponds are located in upland fields to broadly distribute runoff detention. They are linked by 3 meter (10 foot) filter strips of native herbaceous cover to create a detention and filter necklace running parallel to the slope (Richardson and Gatti, 1999),
- Off-channel ponds for nutrient uptake by plants are located every 2.4 km (1.5 mile) at county drain tile outlets to the stream (Woltemade, 2000).
- Off-channel ponds are located at all road crossings of streams to capture sediment and runoff from roads.
- For off-channel storm water storage along low gradient reaches of the stream, ponds are constructed at locations up to 60 m (200') from stream center

Along streams, buffer strips dominated by native perennial vegetation extend 50 or 100 feet (15 or 30 meters) from stream center. Planting within this buffer strip is modeled after the successful demonstration on Bear Creek by Iowa State University researchers (Isenhart et al., 1995). Buffer vegetation is almost entirely riparian woodland, but there are some herbaceous gaps less than 10 feet (3 meters) long to create more diverse aquatic habitat than an entirely shaded stream (Henry et al., 1999).

Farmsteads, towns, and cultural practices. In 2025, 25 percent fewer farmsteads remain than in 1994. Management requirements for rotational grazing keep 50 percent more farmers on the land compared with Scenarios I or III. Roadsides are mown only annually, after nesting and brooding season for birds. In addition, the beauty of the rural landscape brings vacationers to rural areas. These visitors contribute directly to farm incomes and to the economies of nearby small towns.

Expected effects: Landscape network. In Scenario II, a landscape ecology network is formed by water quality management practices, like wider stream buffers, off-channel detention ponds, drainage discharge ponds, along with perennial native herbaceous plants in filter strips, precision agriculture patches, and selectively mown roadsides. These areas are not managed to control invasive species, but along with forage fields and pasture, they are likely to improve habitat for birds and small mammals (Warner, 1984; Warner et al., 1984; Fahrig and Merriam, 1985; Basore et al., 1986; Freemark and Merriam, 1986; Best et al., 1995). Overall the landscape network will have more redundant connections, a wider stream buffer, and a greater diversity of native plant species than Scenario I or the 1994 landscape—all of which are expected to enhance habitat values (Henry et al., 1999; Dale et al., 2000).

Expected effects: Landscape grain. Scenario II displays a range of landscape grains: from coarse-grained landscapes of large cultivated fields and pastures to a comprehensive system of fine-grained water quality BMP's. These BMP's along with rotations and grazing also increase landscape heterogeneity compared with Scenario I.

Expected effects: Water quality and quantity. Continuous cover created by intensive rotational grazing, hay and pasture (Lyons et al., 2000) along with the comprehensive network of innovative detention and discharge ponds (Richardson and Gatti, 1999; Manale, 2000), traditional BMP's, including fenced stream buffers, and broader stream buffers with off-channel detention ponds should improve water quality and flow regimes (Owens et al., 1996; Larson et al., 1997).

Expected effects: Agricultural production. Based on recent prices for beef and dairy products, direct market returns are likely to be low for Scenario II. However, federal policy incentives to protect water quality could increase economic returns to farmers (Countryman and Murrow, 2000; Forster et al., 2000; Manale, 2000).

Expected effects: Public acceptance. Farmers may see the intensive management required for rotational grazing as too time-consuming, and current prices may make it difficult for farmers to imagine adequate returns on a rotational grazing enterprises. However, agricultural communities that are reluctant to accept the environmental effects of expanding CAFO may prefer the quality of life under Scenario II (Jackson et al., 2000), and the general public would be likely to find the Scenario II landscape highly attractive (Nassauer, 1988; 1989; 1992; Schaumann, 1988).

Figure 2 (Above) Aerial view of Scenario II in Walnut Creek watershed shows pasture and forage crops adjacent to fenced streams (Digital imaging simulation: M. Sundt).

Figure 3 (Right) Aerial view of Scenario III in Walnut Creek watershed shows biodiversity BMPs: perennial strip intercropping, linking streams and bioreserves. (Digital imaging simulation: M. Sundt).

Scenario III: Enhancing biodiversity within agricultural landscapes

Under Scenario III (figure 5), the leading goal of federal agricultural policy is to enhance biodiversity within agricultural landscapes. Federal land purchases create a comprehensive system of indigenous species bioreserves of at least 640 acres (260 ha) that are connected by a network of wide habitat corridors that buffer streams. Federal support for innovative, biodiversity best management practices (BBMPs - e.g., perennial strip intercropping and agroforestry) is targeted to a biodiversity target zone that further connects and buffers the new bioreserves. Beyond the biodiversity target zone, corn and soybeans are grown on soils that are highly suitable for cultivation.

Field patterns and livestock enterprises. Federal policy targets BBMPs to 40 acres (16 ha) parcels adjacent to streams and reserves (figure 5). Within the biodiversity target zone, land that is most suitable for cultivation is planted to organic monocultures in fields of 3 to 20 acres (1.2-8 ha) or organic strip intercropping in fields greater than 20 acres (8 ha). Agroforestry, including timber production and mast crops, is planted in patches at least 10 acres (4 ha) along streams on less productive soils.

Perennial strip intercropping (figure 5) is a hypothetical technology invented for this scenario (Nassauer and Corry, 1999). It adapts strip intercropping (Cruse, 1990; Exner et al., 1999) and retains its production advantages, but includes a perennial native prairie strip to enhance habitat values. It consists of 4 to 8 rows of corn adjacent to and rotated with 4 to 8 rows of soybeans adjacent to 39 feet (12 meters) of perennial planted prairie. Strip

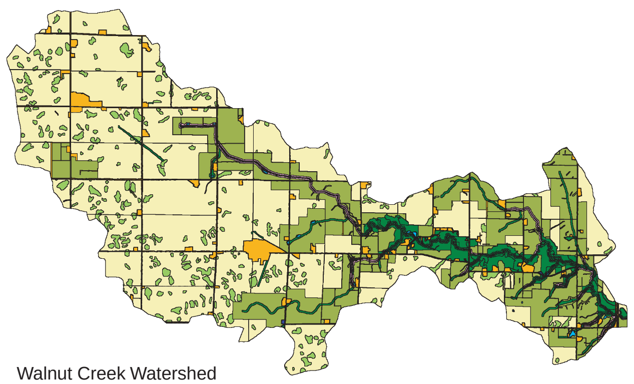


Figure 4 Scenario II landcovers to improve water quality and flow regimes for Buck Creek (right) and Walnut Creek (above) watersheds.

widths vary with the rotational sequence to ensure discontinuous monoculture cropping.

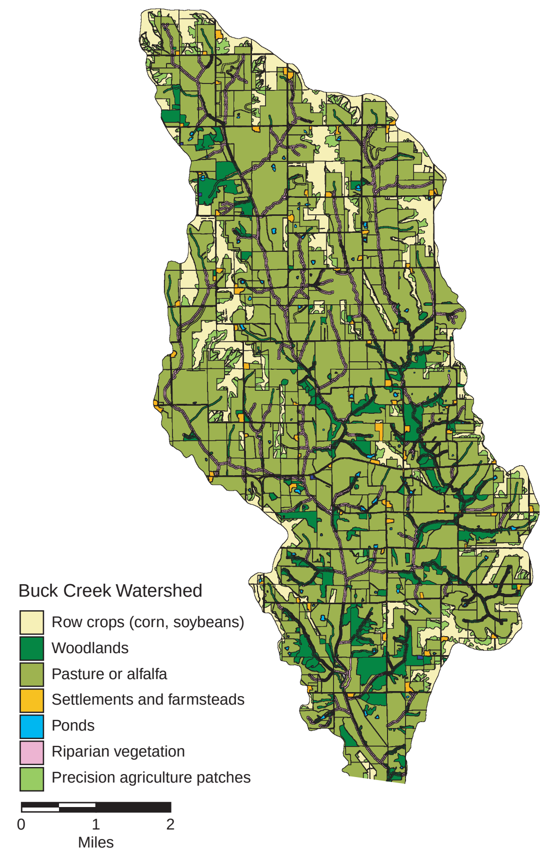
For the purposes of mapping Scenario III, Land Capability Class (LCC) is used as a measure of soil productivity. Beyond the target zone, fields that include at least 50 percent highly productive land at least 3 acres (1.2 ha), or at least 40 acres (16 ha) in area if the land is not part of a larger field, are cropped in a conventional corn/soybean rotation implemented with no-till and conventional BMP's planted to perennial native herbaceous vegetation. Corn/soybean/oats optional strip intercropping is employed in other fields outside the target zone. Like Scenario I, Scenario III assumes that livestock are raised in CAFOs in a few locations in the state (Jackson et al., 2000). No pasture and little hay are on the land.

Conservation practices. No-till cultivation practices and conventional BMP's are applied outside the target zone. Within the target zone, the biodiversity BMP's described above are applied. The target zone connects wide buffers along the streams with bioreserves.

Bioreserves are located on soils of the appropriate indigenous ecosystem type, (e.g., a wetland reserve on hydric soils). Pre-settlement vegetation also is used to identify reserve sites so that each indigenous ecosystem type is represented in the reserve system.

Bioreserves are designed to maximize indigenous ecosystem heterogeneity within a broad ecosystem type (e.g., wetlands should include perennial and ephemeral conditions) and maximize interior conditions within an ecosystem type. Each reserve is located to achieve the goal of 640 acres (260 ha) without roads, trails, or houses. Because the scale of many ecological functions exceeds the size of a second order watershed, reserves are sited near watershed boundaries to enhance flows across watersheds. To maximize interior conditions, sites that meet the primary selection criteria for two different ecosystems and are adjacent to each other, for a larger total reserve size, are preferred. To make the best use of local cropland, the core reserve is extended wherever adjacent land of at least 40 acres (16 ha) has soils that are relatively unproductive.

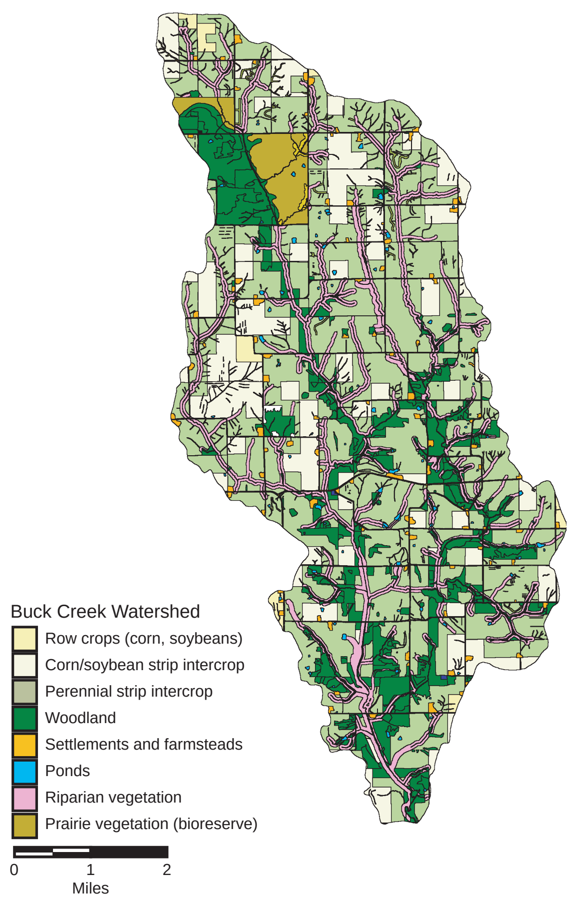
To manage the flow of species, materials, and nutrients across



reserve boundaries, filters are designed along reserve edges. Run-off is detained at the edge of roads. To help drivers see animals crossing roads, woodland reserves are buffered from state highways or freeways with a 165 feet (50 meter) herbaceous edge. To discourage predation by domestic pets, houses are purchased and removed from core reserves, peripheral reserve areas, and adjacent to core reserves.

Riparian woodland buffers extend 100 feet (30 meters) from the center of ephemeral streams, 200 feet (60 meters) from the center of perennial streams, and 300 feet (90 meters) from streams where a recreational trail runs along the riparian corridor edge. Trails are sited at the edge of the widest parts of stream corridors and enter the reserves only at the visitor centers to avoid fragmentation of corridor habitats.

Farmsteads, towns, and cultural practices. For Scenario III, farm size increases and the number of farms diminishes as in Scenario I. However, nearly all of the farmsteads present in 1994 remain inhabited under Scenario III because of an influx of new non-farm residents to the countryside. These new residents are attracted to the agricultural landscape for its amenity values, like wildlife that is seen around the network of corridors and core reserves, and opportunities to use trails. Population slightly increases compared with 1994, and local retail and service economies thrive (Beck et al., 1999). Roadsides are planted with native herbaceous plants, and are mown only annually in late



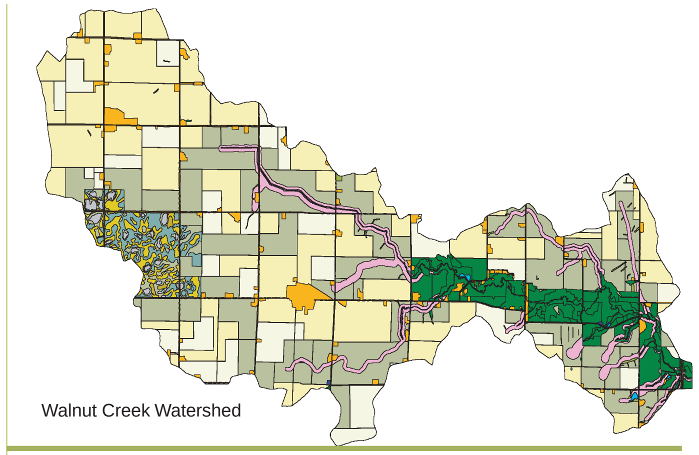


Figure 5 Scenario III landcovers to enhance biodiversity within agricultural landscapes for Buck Creek (left) and Walnut Creek (above) watersheds.

summer to prevent encroachment by woody species. Bioreserves are designed to teach people about indigenous ecosystems but to discourage people from entering the core reserve.

Expected effects: Landscape network. In Scenario III, policy creates landscape networks. Core reserves established for every major indigenous ecosystem type (e.g., wetland, riparian woodland, etc.) within the watershed greatly enhance habitat for specialist indigenous species (Dale et al., 2000). The network of wide stream buffers and BBMPs supports species movement and population viability.

Expected effects: Landscape grain. The most widely used BBMP, perennial strip intercropping, creates a fine-grained matrix of native species interwoven with annual crops in the target zone around all streams and reserves. Organic crops in small parcels of highly productive land within the network are expected to support invertebrate diversity.

Expected effects: Water quality and quantity. The target zone enhances water quality by its breadth and pervasiveness in the landscape (Watzin and McIntosh, 1999; Countryman and Murrow, 2000). Perennial strip intercropping, and roadside native planting will take up nutrients, hold sediment, and detain surface water (Chow et al., 1999; Eghball et al., 2000). The wider stream buffer in Scenario III captures sediment and nutrients, promotes bank stabilization, and detains storm water (Henry et al., 1999). It also creates a diversity of riparian and aquatic ecosystems. Indigenous ecosystem core reserves will be large enough at 640 acres (260 ha) to create opportunities for groundwater recharge as well as detention of surface water. These features are expected to improve water quality and reduce stream flashiness (Larson et al., 1997).

Expected effects: Agricultural production. Direct market returns could be quite high from the Scenario III landscape, which includes strip-intercropping of corn and soybeans, as well as more unusual perennial strip intercropping with prairie seed production, and organic crops (Rickerl et al., 2000). Agroforestry would provide more long-term economic returns (Countryman and Murrow, 2000). An economic model that includes returns from tourism and from the secondary service economy of a more populous region might further reveal the economic value of the Scenario III landscape (Beck et al., 1999).

Expected effects: Public acceptance. Farmers are expected to value populous rural communities in Scenario III. Farmers and the broader public are likely to value appropriate use of productive Corn Belt soils and enhanced stewardship of less productive areas (Nassauer, 1988; 1989; 1992; 1997). Because farmers are concerned about the environmental quality of the land where they work and live (Northwest Area Foundation, 1995; Lovejoy et al., 1997), and because Corn Belt farmers have shown considerable capacity to innovate in response to federal agricultural policy, they may find Scenario III innovations desirable.

Future landscape scenarios to illustrate policy choices

Contrasting the three alternative landscape scenarios with the 1994 Corn Belt landscape illustrates the power of present and future agricultural policy choices to affect agricultural practices and ecological health, and to affect the broader public's experience of American agriculture. This suite of three alternatives was designed to integrate scientific knowledge from many disciplines into plausible landscape futures that would emphasize the range of choices available. To see more simulations of the future and read the detailed landcover change rules, go to http://www.snre.umich.edu/faculty-nassauer/lab_index.html.

Different combinations of some of the policy goals and agricultural practices illustrated here could be implemented to achieve a future landscape that balances policy goals in a different way (Cox, 2001). Practices and technologies that we did not imagine will undoubtedly emerge as well. They too will point the way to achieving agricultural policy goals. These scenarios should show that policy choices are possible and their effects dramatic, in the same way that the early 19th century General Land Office survey, the early 20th century establishment of the Soil Conservation Service, and the mid-20th century price support programs dramatically affected the agricultural landscape.

Is it possible to have a healthy United States agriculture system, help feed the world, and reclaim agricultural landscapes as healthy places to live and delightful places to visit all at the same time? Is each of these ideas a legitimate goal of federal agricultural policy? Should we have to trade any one of these societal goods for another? The scenarios described here and the related assessments to test their expected results are intended to help policymakers imagine answers to these questions (e.g., Coiner et al., 2001; Santelmann et al., 2001; Vache et al., In press).

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