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## Strategic Plan for the Gordon Natural Area

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**Strategic Plan for the Gordon Natural Area  
March 1, 2012**

by

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[website: [www.gordonarea.org](http://www.gordonarea.org); facebook: Gordon Natural Area]

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## **Executive Summary**

The Robert B. Gordon Natural Area (GNA) for Environmental Studies located on the south campus of West Chester University (WCU) was officially established in 1973 with the threefold mission of education, research and the protection of biodiversity. As of Fall of 2011, 29 classes from 12 Departments and five Schools use the GNA as part of their classroom experiences. Research efforts by the faculty began in 1969 when the now deceased Dr. William Overlease established permanent plant monitoring plots on the SW corner of New and Tigue Rds. Research has been conducted by Dr's Harry Tiebout, Win Fairchild, Greg Turner and Gerard Hertel of the Biology Department. Non-native plant control (clipping, hand pulling & biological control) has gone on since 2004. Tree restoration began in 2006 with grants from Tree Vitalize/AQUA America. The GNA also provides students, faculty, staff and local residents (and international residents-the Kenyan running team located in West Chester) abundant opportunities for recreation and the enjoyment of the outdoors. Ecosystem services provided by the GNA include gas regulation (produce oxygen/use and store carbon dioxide), flood prevention, water regulation/supply, soil retention/formation, nutrient regulation and habitats for plants and animals. The GNA is an important piece of landscape in a county (Chester) that has lost 25% of its tree cover in the last 10 years and a township (West Goshen) that has lost 20% of its forest cover in the last 10 years. Current management policy provides minimal protection for the area. Concerns have been raised about the current condition of the forest and about the risk that a future road poses to the property. Deer, invasive plants, non-native earthworms and trail bikers continue to impact the native flora and fauna. Too much stormwater in the East Branch of Plum Run is destroying the banks and riparian areas. This paper reviews the need for perpetual protection of the GNA. This plan focuses on protecting, restoring and enhancing the GNA's research, educational and ecosystem assets. Action items are listed on page 11.

## **History of the Robert B. Gordon Natural Area**

In 1971, exactly one year after the very first Earth Day, WCU's Board of Trustees (encouraged by two students) acted boldly and with great vision to protect the natural lands of south campus. Their intent was to set aside some land (in honor of Earth Day) to preserve the existing native vegetation and to be used for ecological and other biological studies. In November 1973, the late Dr. William R. Overlease, Professor of Biology at WCU, formally dedicated this property. It was named the Robert B. Gordon Natural Area for Environmental Studies in commemoration of Professor Gordon, a science faculty member at WCU for 25 years.

## **Who was Robert B. Gordon?**

Robert B Gordon was a true lover of plants from the stateliest primeval trees to the humblest of mosses. A member of the science faculty for 25 years, nearly 20 as Department Head, Dr Gordon was particularly interested in local flora. Among his many publications were "Natural Vegetation of West Goshen Township" and "A Summer Key to the Genera of Native Trees Likely to be Planted in Chester County."

Dr Gordon was an avid collector of plants which he donated to collections in New York and Ohio where he has cataloged vegetation prior to coming to WCU. His interest in collecting made him an ideal curator for WCU's highly regarded Darlington Herbarium.

During the summer Dr Gordon was active far afield from WCU. He returned to Ohio to complete his best known work, "Ohio's Original Vegetation" a map of Ohio showing vegetation present upon arrival of the first non-native American settlers. He also taught for several seasons at the Audubon Nature Center.

After retiring in 1963, Dr Gordon was named Professor Emeritus of the sciences. He remained active, often joining the wildflower walks offered to the public in the Natural Area named in his honor and telling participants amusing anecdotes.

It is fitting that a man who so enjoyed the outdoors should have a natural area rather than a building bear his name. (See History Section at <http://www.gordonarea.org/>)

## **Features and Resources on the Gordon Area**

### **Maps (see appendices)**

- Map 1. Location of the GNA in the Plum Run Watershed (part of the Brandywine Watershed that is part of the Christina Basin that flows into the Delaware River)
- Map 2. Proposed GNA
- Map 3. Historical land use-proposed GNA over 1937 aerial photo
- Map 4. Management Units, 1,2 3
  - Map 7 Management Unit 1
  - Map 8 Management Unit 2
  - Map 9 Management Unit 3

### **Species lists**

- Plants (see [http://www.gordonarea.org/biodiversity\\_plants.html](http://www.gordonarea.org/biodiversity_plants.html))
- Birds (see [http://www.gordonarea.org/biodiversity\\_animals\\_birds.html](http://www.gordonarea.org/biodiversity_animals_birds.html))
- Stream invertebrates (DeFederico's MS thesis)
- Amphibians & Reptiles
- (see [http://www.gordonarea.org/biodiversity\\_animals\\_birds.html](http://www.gordonarea.org/biodiversity_animals_birds.html))

**Research projects ([http://www.gordonarea.org/research\\_local.html](http://www.gordonarea.org/research_local.html))**

Plant succession in an abandoned farm field (Overlease-retired/deceased)  
 Forest health monitoring (Hertel-adjunct-funded by the USDA Forest Service)  
 Stream quality (Fairchild-professor-funded by Pennsylvania Sea Grant)  
 Effects of deer and invasive plants on native trees (Hertel-funded by Wildlife Resources Fund, DCNR and USDA Forest Service)  
 Salamanders (Tiebout-professor-funded by WCU Technology Fee Grant)  
 Effects of garlic mustard (Turner-Associate-funded by Center for Invasive Plant Management)

**Class activities (See Appendix Table 1)**

**Ecosystem services provided by the GNA-**

1. gas regulation (intake & storage of carbon & production of oxygen)  
uptake of air pollutants by roots & leaves
2. disturbance prevention (structure & storage capacity of vegetation can reduce effects of floods & droughts)
3. stormwater regulation/supply
4. flood abatement
5. soil retention (roots of plants stabilize the soil and foliage [leaves] intercepts rainfall)
6. soil formation (accumulation of plant material)
7. nutrient regulation (proper nutrient cycles are maintained)
8. living space for plants and animals
9. pollination (provides habitats for insects & birds that pollinate plants)
10. aesthetics (people enjoy scenery & landscapes)
11. recreation (places for relaxation & recreation)
12. historical information (gives us a sense of continuity & place; a linkage to Penn's Woods)
13. science & education

**Why the Gordon Area needs a strategic plan**

The GNA is an ecological treasure island located in a sea of urban development. It is a natural asset whose value exceeds any building on campus. Like a building, it needs planned maintenance to assure that its long-term environmental and educational benefits can be maintained and enhanced. In order to assure ecologically sustainable conditions (avoid depreciation of the asset) a strategic plan is a must.

Since its establishment in 1973 the GNA had not been managed. The result was that by 2005 it continued with no permanent protection status, was threatened on a regular basis by road construction, white-tailed deer, invasive plant species, trail bikers, and stormwater damage to its waterways. In 2006 we received a temporary part-time position and some operating funds to manage the area. That temporary funding will continue until June 30, 2012.

New green space protections have been requested in 2012 by East Bradford Township that could add acreage to the GNA. The Township has also requested a permanent protection easement of the 26 acre floodplain/wetlands/old farm field west of New St. and south of Tighe Rd. A six acre land donation could be added to the Big Woods section of the GNA in 2012 or 2013

The university finds itself in a unique position. Will we be good stewards of this ecological treasure or act as pirates, take what we can get, and leave nothing for future generations. The implementation and funding of this plan will assure a conservation legacy for WCU.

#### **Transformation Goals (adapted for this project) from WCU Strategic Plan**

1. responsiveness: WCU a recognized leader in conservation/green space issues and solutions
2. student success: opportunity to participate in a real-world land use decision making process as part of educational experience
3. human capital: faculty on-campus experiences contributes to their effectiveness in the community where they live
4. resourcefulness: WCU recognizes that the GNA is an important facility of the WCU campus and grant money in support of the GNA will be increased

A new WCU Strategic Plan will be completed by this spring (2012). We are providing input into that plan and anticipate that the Gordon Natural Area will be identified as an important educational and research component to this University.

The importance of the GNA was highlighted on the web site for 2012 Knowledge Crossing Borders Conference (May 2012) where in a three paragraph description of WCU the GNA was described ... "a conserved natural area providing opportunities for research and educational programs."

## **Mission Statement for Gordon Natural Area and Current Rules**

### **Mission:**

- To preserve a natural area. All forms of human disturbance are to be minimized. This limits the types of activities that can be conducted in the GNA.
- To serve as a natural laboratory for environmental studies. The GNA is to be used for teaching and research in ecology and related environmental disciplines, not as a recreational facility.

### **Regulations:**

- Stay on marked trails only
- Trails are open dawn to dusk only
- Pets must be on a 6' or shorter leash
- Please clean up after your pet
- No fires, no smoking
- No camping
- No fishing or hunting
- No moving, damaging, or collecting plants, animals, or natural objects
- No bikes or motorized vehicles
- No littering
- No alcoholic beverages

### **Threats**

#### **1. Loss of educational assets**

Disturbances of the contiguous forest in the GNA are causing a decline and local extinction of plant and animal species. Invasive plants, non-native earthworms, deer, and trail bikers are causing losses of plant and animal species and changing the diverse natural landscape into a simple one. These impacts, if left unchecked, will lessen the opportunities for teaching and research.

#### **2. Losses in environmental stewardship**

West Chester University (WCU) should develop in its students a high degree of social, economic and environmental responsibility. Dedicating resources to properly steward the GNA would set an example for our students and assist them in realizing a sense of environmental and social concern. This represents an opportunity for “real-world” “hands-on” learning experience. WCU has the opportunity to highlight the large role our land and biological resources play in sustaining the environmental quality of the wider community and in preserving one of the best remaining linkage (and only public linkage in West Goshen Township) to Penn’s Woods in the area. Management resources were provided for the first time in 2006 and will continue at least through June 30 2012.



### **3. Fragmentation**

Fragmentation (conversion of large areas of contiguous native forest to other types of vegetation and /or land use leaving remnant patches of forest that vary in size and isolation) is second only to outright conversion of forestland to other uses (houses, malls etc) as a cause of ecological degradation. Forest fragmentation results in the local extinction of species and can lead to far lower overall species diversity than would occur if the same total area of forest were to remain as a single contiguous block. Minimum-area requirements vary greatly among species. Many plants as well as animals are forest-interior specialists, unable to utilize the outermost zone of forest near the edge as habitat. They need at least 300 ft. of buffer from the closest edge. The area inside a forest, but near its edge, is vulnerable to a host of detrimental outside influences, including increased wind, light and heat, decreased humidity, and the influx of seeds of invasive introduced species. In general, fragmentation favors invasive species and works against native species.

In this part of Chester County, fragmentation has been severe. The good news for the GNA is that rather than being fragmented by WCU it could be added to. A road was put through the GNA in 1972 for graduation and football games. The tree crowns have closed over that road so that the total area is behaving as an interior forest habitat. Opening a wider public road over the existing road would break the contiguous forest in two parts resulting in no more interior forest habitat. Significant time and energy was put into stopping the public road in 2004/05 and again in 2010.

### **4. Invasive plant species**

The destructive impact of invasive plants on native biodiversity is exceeded only by habitat conversion and fragmentation. An invasive species is one that rapidly spreads and out competes native species. By displacing native vegetation, invasives simplify the structural and food resources of a site, reducing its habitat value for native fauna, particularly native insects and migratory songbirds. Historically, trees/forests were removed for fuel, wood products and clearing for agriculture. Those activities coupled with the more recent residential and commercial development have effectively removed most of the native vegetation near WCU. Forest edges are highly favorable to the entry and proliferation of invasives. In 2007, the Department of Biology identified the plant species that are invading the GNA. At least 20 invasive plant species are well established in the GNA and more than 30 other introduced species also are common. Norway maple, tree-of-heaven, Japanese stilt grass, garlic mustard, multi-floral rose, barberry, oriental bittersweet and Japanese and Amur honeysuckles are the main culprits.

### **5. Deer**

Forest fragmentation, killing off of large predators, and conflicts over hunting have resulted in the proliferation of the white-tailed deer that has resulted in the reduction of plant species diversity in the forest understory. Deer have moved the deer tick with his



disease causing organism(s) over large areas. The impacts to the GNA are significant. The deer density has been so high (we estimate that about 90 deer are in the GNA as of 9/5/05) for so long that many species of tree seedlings are virtually absent from the forest floor. The carrying capacity for deer on the GNA is six. Baby native oaks, which are highly preferred food for deer, can no longer be found. Although there is regeneration of a few species (American beech and white ash) less preferred by deer, the number of seedlings is barely adequate to sustain a forest into the future. Deer move from the GNA and feed in the urban landscape doing a lot of damage in residential properties. They also cause accidents while crossing Tigue, New and probably High Streets. Ironically, man is the only species left in the area capable of maintaining the population density of white-tailed deer low enough to keep them from destroying the GNA. The stewardship staff is currently considering alternatives for long-term deer management (see <http://www.gordonarea.org/pdf/deermgmtplan09.pdf>)

## **6. Earthworms**

Have you ever walked in a hardwood forest and noticed that the forest floor is firm underfoot, bare ground and fine roots are visible, and very few understory plants are present?. The culprits are non-native earthworms and they are changing forest ecosystems.

Changes in forest composition after earthworm invasion will be complex, and will interact with other agents of global change, such as increasing climatic temperatures. It is possible that warmer temperatures, deer, and earthworms will work synergistically to change temperate forest ecosystems much faster than any one of these factors alone.

The cumulative impact of an earthworm invasion on many native plant species is substantial and results in significant changes in community composition. At the same time, exotic plants preferring mineral soil seed beds, such as garlic mustard may be better adapted to the earthworm-worked soil conditions. Therefore, the spread of these exotic plant species may actually be facilitated by earthworm invasions.

## **7. Uses that Impact the GNA**

### **a. Walking/hiking on trails**

From a purely natural resource perspective, trails and roads can potentially have detrimental effects on the forest, both ecologically (creating migration barriers and “killing fields” for certain organisms) and environmental (forming channels for stormwater). In addition, human users of trails can unknowingly carry seeds of new invasive plants into the GNA. However, given that recreational use is common, trails are the best way to direct that use. The main concerns with walking trails are (1) limiting the number of trails to minimize soil exposure, (2) properly routing trails to direct users of the GNA through and to where they should go and away from where they should not go, and (3) minimizing soil erosion potential through proper location, construction and maintenance. The major trails in the GNA were created long before WCU owned the property and parts of these trails need rerouting. Bikers have created many new trails that

must be closed. A trail inventory will be completed in 2011. Trail closing (steep and eroded sections) and rerouting began in 2007 in conjunction with a Eagle Scout project.

#### **b. Trail bikes**

Bicycles can be relatively benign in natural areas under certain conditions (large area, low frequency). Repeated use of trails has accelerated trail erosion by funneling stormwater into narrow, continuous channels. Off-trail exploration, common in the GNA, disturbs understory plants and wildlife. Bikes threaten both the safety and recreational enjoyment of pedestrians. The current type and level of use has created conflicts with walkers, degraded trails, and disturbed off-trail vegetation. WCU should continue to prohibit bikes in the GNA. More enforcement is needed

#### **c. Dog walking**

People walking leashed dogs can be compatible with the mission of the GNA if they are limited to the established trail system. Unleashed dogs are not a compatible use given the academic, ecological, and recreational priorities for the GNA. Unleashed dogs threaten the safety and recreational enjoyment of other users. In June 2005 a student in a class in the GNA had his clothes ripped by an unleashed dog. WCU has established a pet policy that protects visitors and natural resources and has informed the community through appropriate signage. If visitors refuse to comply with the policy, WCU should consider revoking this privilege.

### **8. Material and equipment storage and disposal**

Several locations next to the GNA are being used for the storage and disposal of various building and landscaping materials. One of these is in the SE corner of the GNA near the 202 bypass entrance/exit. The open ground is used as a dumping ground for plant debris generated by the removal of plant material from the university grounds. This practice can pose a threat to the health of the forest. Such materials are foreign to the native forest ecosystem and behave very differently from forest litter-fall. They may have non-forest seeds, insects, fungi, bacteria, and chemical properties, some of which can cause harm to native forest species. They are placed in piles or thick layers and take much longer to decompose than the thin layers of litter that are laid down naturally in the forest. These piles can provide favorable conditions for new invasive plant species. We encourage the use of another site but understand that there may be no alternative.

### **9. Paintball games/Geocaching/Orienteering**

Even though the paint used in this activity is usually environmentally benign, paintball games cause damage to understory vegetation, harass wildlife and, in the end, leave an unsightly mess. In mixed-use situations paintball games can be hazardous and disturbing to other users. This activity is inappropriate for the GNA and should be listed on signage

as not permissible. There was evidence of this activity in the summer of 2004. None has occurred since.

Geocaching (<http://www.geocaching.com/>) and orienteering (<http://orienteeringusa.org/>) are not permitted because of the disturbances that could be caused in off-trail activities.

## **10. Construction of a public road**

The Brandywine Conservancy, in its recent Environmental Assessment of the GNA, determined that our current private road does not negatively impact the ecological integrity of the GNA. This is partly because our private road is so narrow (a single lane without shoulders) that it does not produce a gap or opening in the forest canopy and partly because of low traffic speeds and volume by the university grounds people.

In contrast, a wider public road would result in significant harm to the GNA. Undesirable ecological impacts would include: (1) increased wildlife mortality from higher and faster traffic volume, (2) habitat fragmentation caused by opening the forest canopy, which will result in an increased invasion by unwanted invasive plants and a subsequent loss of some native species, (3) increased number of visitors (which will increase the amount of off-trail hiking and biking, collecting of plants and animals, and dumping of litter and trash), (4) increased problems associated with more impervious surface area (run-off of gas, oil, salt, and other pollutants into the GNA and more storm water run-off into the watershed), and (5) damage from construction that will impact a much larger area of the GNA than the final footprint of the road.

In addition to the ecological impacts, a wider public road would also seriously degrade other values of the GNA by (1) reducing access by classes (we currently can park vans along the side of our private road for easy access to any part of the GNA), (2) compromising student safety (there are two major trail crossings along our private road), and (3) by disturbing student and faculty teaching and research sites.

## **11. Suburban land-use impacts to water quality**

Sediment is generated by storm runoff from construction sites, roadways, parking lots, lawn areas, and unstable stream banks. Excessive sediment in streams can harm other aquatic life, particularly bottom-dwelling species. The erosion and sedimentation problems facing the Plum Run watershed can be attributed to its high residential/university/ development and its resulting stormwater runoff. Phosphorus is often contained in runoff from lawns and gardens using chemical fertilizers. Phosphorus is the main nutrient responsible for eutrophication (nutrient enrichment, which causes algae blooms) in waterways. As algae decompose, they consume dissolved oxygen and diminish the ability of the creek to support healthy populations of aquatic life. Additional threats to the quality of both surface water and ground water resources include:

- Chemical or oil spills on roads, with direct drainage to the tributaries or the main



stem of Plum Run, particularly on the 202 exit area for the West Chester bypass where tanker truck accidents are a possibility.

- Chemical or oil spills, leaks or dumping
- Sewage treatment plant malfunctions or overflows, with the potential to release large amounts of disease-causing bacteria, nutrients, and heavy metals. This occurred from WCU's pumping station on south campus during the summer of 2005.
- Pesticides used on residential and university lawns and on university athletic fields.

## **12. Suburban land-use impacts to water quantity**

Almost the entire Plum Run watershed has been cleared of forest, plowed and grazed for agriculture, bulldozed for development, planted in lawns, or paved. Each of these actions generates unnatural rates and amounts of stormwater runoff, particularly in the wettest periods of the year. Water that once infiltrated soil and recharged aquifers to gradually feed wetlands and streams during periods of drought is now lost downstream. As a result, the frequency and extent of flooding is artificially high, and the water table that allows groundwater to feed wetlands and supply the base flow of streams is artificially reduced to unnaturally low levels during the driest periods of late summer. Increased surface runoff generated by poorly planned development results in increased flooding and erosion, diminished groundwater levels, increased pollution of ground- and surface water, increased concentration of pollutants, and reduced diversity of native plants and wildlife.

## **13. Erosion and compaction**

The soils of the GNA tend towards instability and are subject to serious sheet and gully erosion, especially in areas without vegetative cover. The GNA experiences the effects of increased runoff and flooding through erosion and sedimentation in the main stem of Plum Run and its tributaries, particularly where unnaturally large sediment deposits form sandbars or islands, and where severe bank erosion and gully erosion is evident. Effects of this trend on vegetation and wildlife in the GNA can include premature mortality of trees undermined by eroding streambanks and decreased diversity of aquatic organisms. Trails are essential for proper recreational enjoyment of the GNA, but they are poorly designed or misused and they have become stormwater channels that cut into slopes and remove organic and inorganic soil components. In severe cases, gully erosion can lower the water table and stress established vegetation. The trail system that has evolved in the GNA effectively serves the recreational needs. There are areas where trails are a threat to soil resources, mainly due to poor (or nonexistent) design. In these areas trails run more or less directly down the slope because it is the most direct route between two points. Mountain bikers continue to create unauthorized trails. This not only results in the formation of potential erosion channels, but tramples understory vegetation and expands the amount of compacted soil within the GNA. Compacted soil results in lower water percolation and soil gas exchange — both detriments to forest trees and shrubs. In some areas invasives are adding to the potential for soil erosion. Invasive trees, particularly Norway maple, create such a dense shade that the soil surface is essentially devoid of

shrubs and herbaceous plants, leaving little soil protection and none at all where part of the canopy is removed by wind-throw.

#### **14. Carbon Storage**

The rates of growth and carbon capture slow in forest stands as a result of aging, and may even decline at advanced ages due to increasing natural mortality. The reduction in growth with age is substantial. The result is that while older forests can store more carbon, the rate at which they remove additional carbon from the atmosphere is substantially lower, eventually plateaus, and can become negative if mortality increases to the point that it exceeds net growth. Because the rate of forest growth slows, then reaches a point where new biomass accumulation is matched by biomass loss, and (sometimes) thereafter even becomes negative, carbon accumulation does not continue forever. ( <http://www.dovetailinc.org/files/DovetailCarbon101Jan2012.pdf>)

#### **Things to Do**

1. Protect in perpetuity this ecological treasure, which serves as the last public land link to Penn's Woods in West Goshen, Westtown and East Bradford Townships
2. Add land parcels to the GNA from both public and private sources
3. Formally re-dedicate the GNA as an important educational example of sustainability by our University on its 40th anniversary 2013 (Monday April 22)
4. Formally use the GNA as part of the perspective and new student/parent orientation to WCU
5. Enforce rules and regulations through partnerships with Security, neighbors and users
6. Engage neighbors, users and other interested publics in the sustainable use and management of the GNA
7. Prepare a trail management plan that includes inventory, rerouting, restoration and safety components. Expand trail system into rest of GNA
8. Develop stewardship plans for each unit. This would be done as student projects in partnership with faculty, users and neighbors
9. Maintain and enhance existing web site and Facebook page
10. Encourage more departments/schools to use the GNA to enhance their student's educational experience and expand their research opportunities.
11. Enhance the oversight of the GNA by establishing a permanent part-time position in the Department of Biology to oversee all activities in the GNA. That person would be a permanent member of the University's Sustainability Advisory Council, with the goal of insuring that all policies for managing the GNA are sustainable.

## Key Publications

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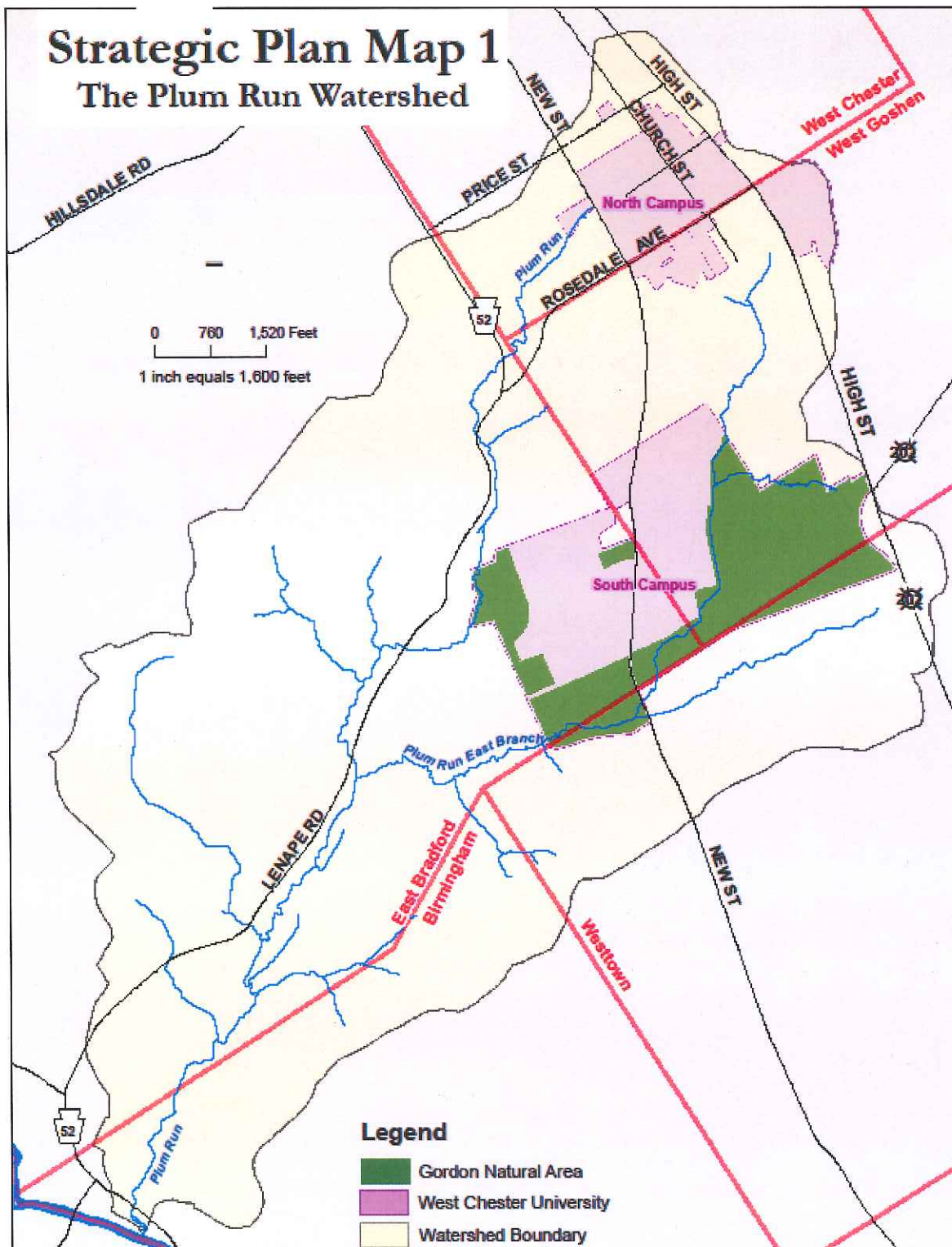
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## Appendices



Map 1 Location of GNA in the Plum Run Watershed

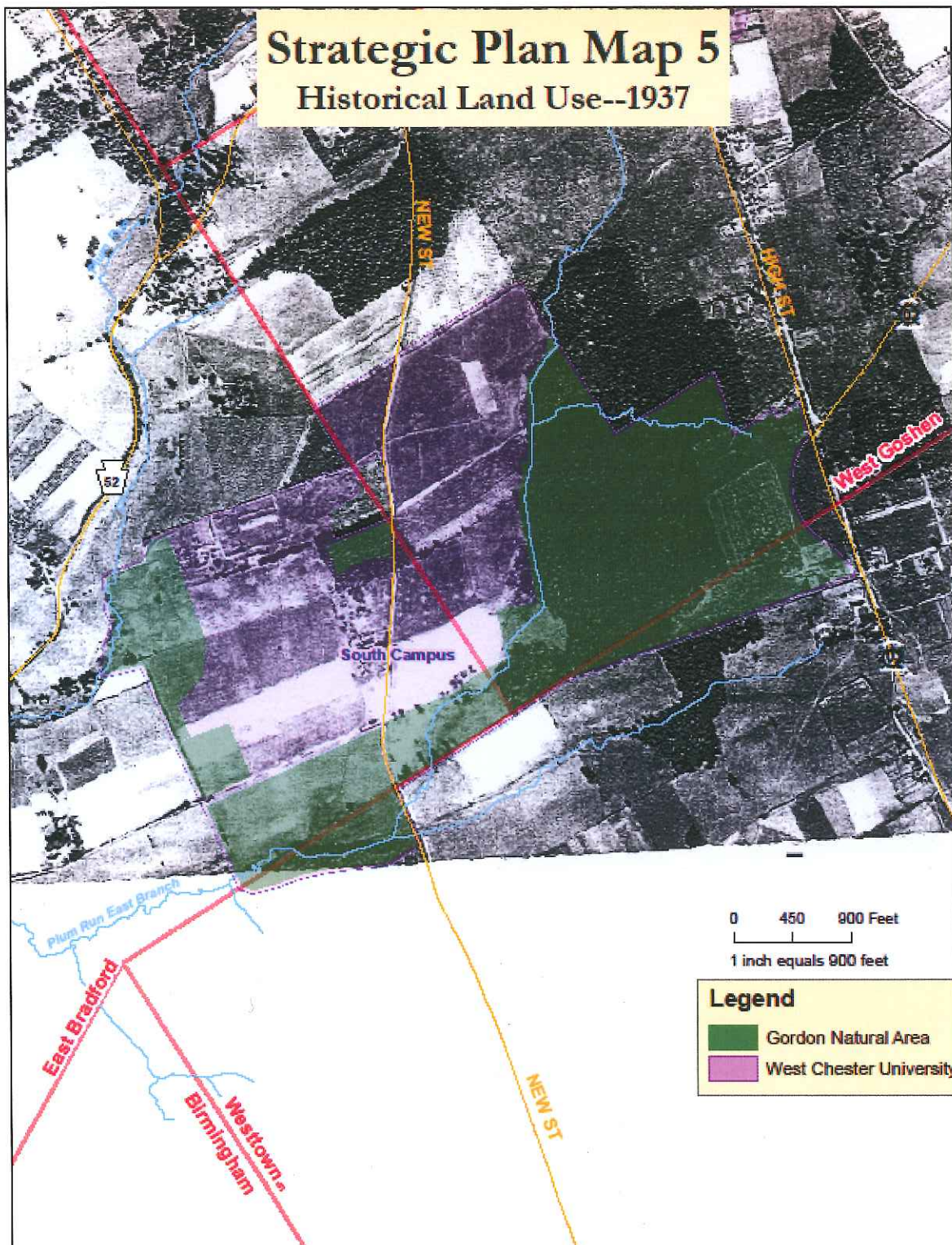


Map 2 Current and proposed GNA



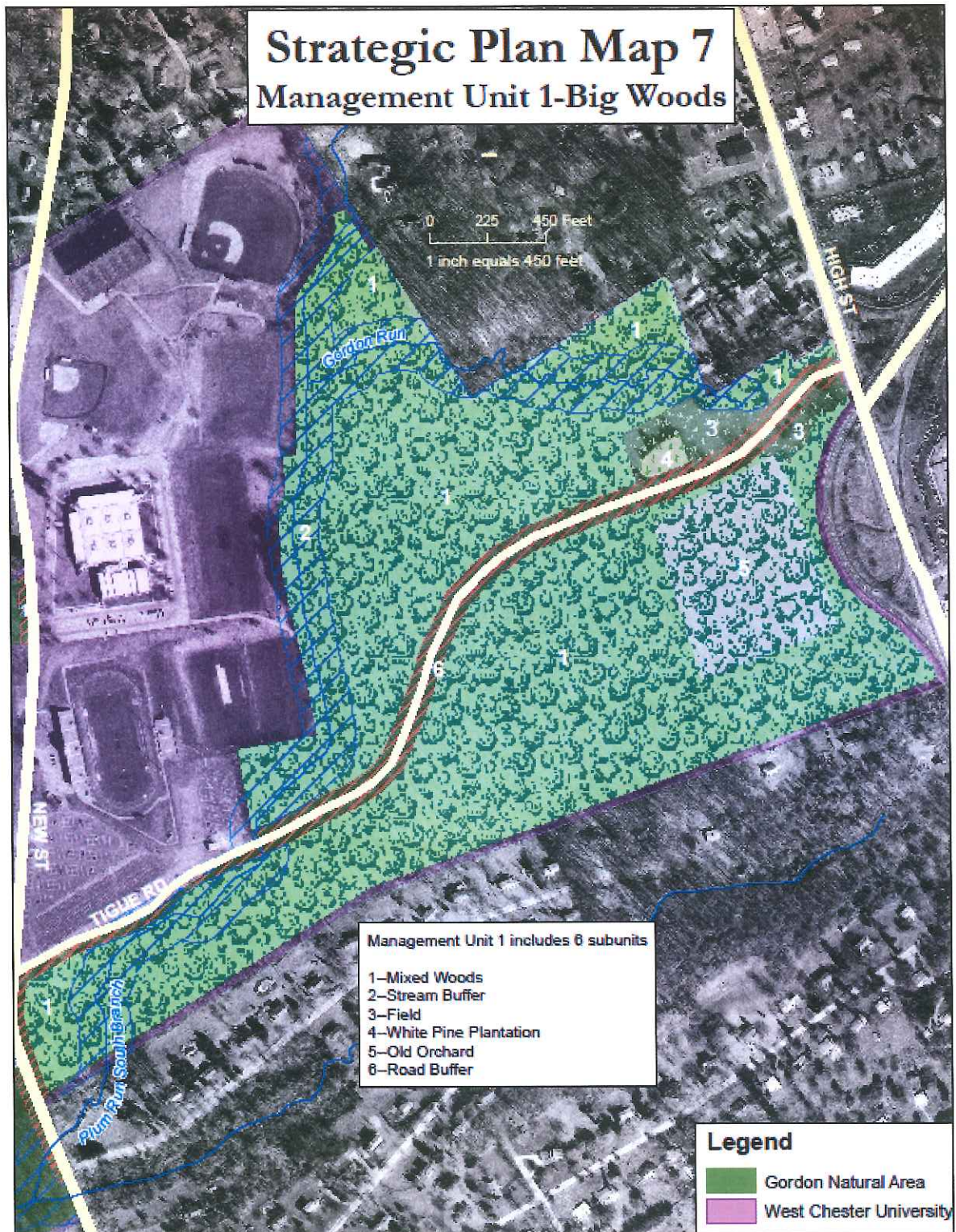


Map 3 Historical land use in the GNA (1937 aerial photo)

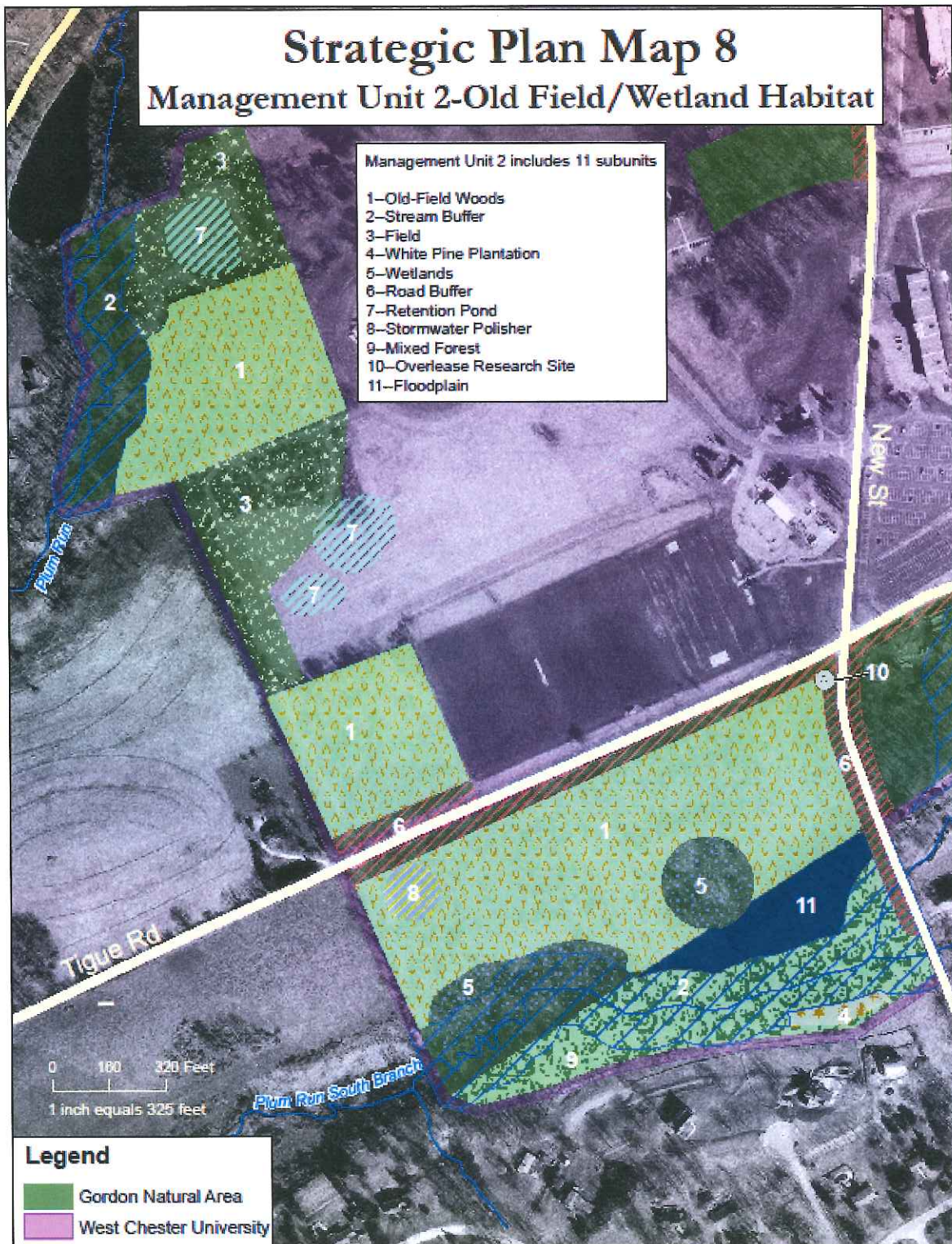




Maps 4 Management units (1,2,3)









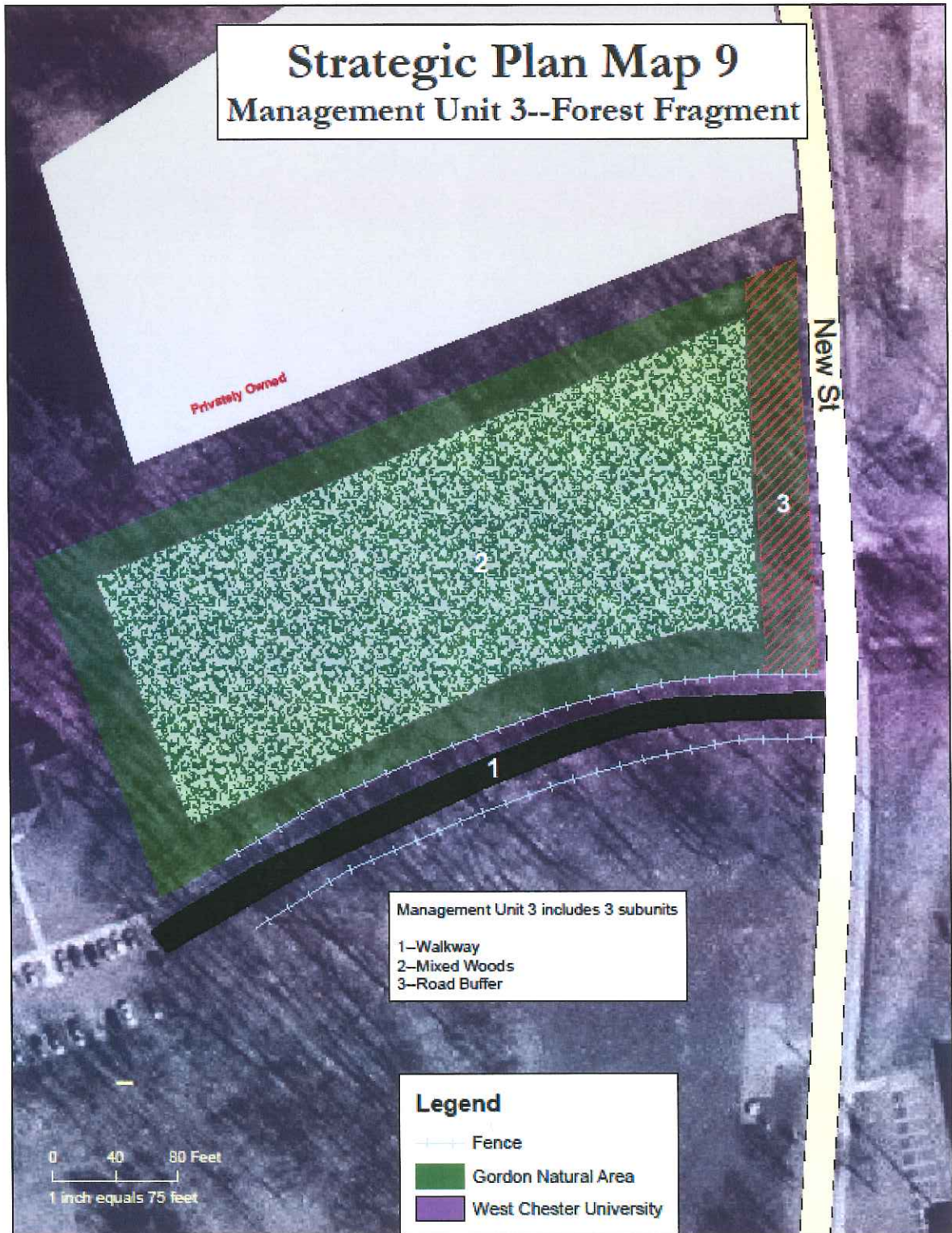


Table 1: Classes that use the Gordon Natural Area

Class/Activity	Department	#	# students/yr	Faculty
Archaeology of Ancient North America	Anthropology & Sociology	364	8	Wholey
Cross Country Team	Athletics		24 (14 women & 10 men)	Huber
Ecology	Biology	270	80	Tiebout
Entomology	Biology	377	14	Boettger
Vertebrate Ecology	Biology	277	14	Tiebout
Mycology	Biology	454	24	Turner
Population Biology	Biology	470/570	14	Fairchild
Freshwater Ecology	Biology	476/576	14	Fairchild
Wetlands	Biology	471/571	14	Fairchild
Event Planning	Communications	499	20	Millhouse
Written Rhetoric: Power, Politics, and Environmental Writing	English	310	15	Comfort
Environmental Applications of GIS	Geography	338/538	36	Coutu
Introduction to Physical Geography	Geography	102	25	Welch
Environmental Conservation and Sustainability	Geography	230	30	Fritschle
Environmental Crises	Geography	332	30	Fritschle
Geographic Field Methods	Geography	585	20	Fritschle
Environmental Geology	Geology	336	12	Lutz
Environmental Geochemistry	Geology	331	24	Lutz
Introduction to Geology	Geology	101	400	Helmke M., Helmke V., Bosbyshell
Soils	Geology	490/590	25	Helmke
Hydrogeology	Geology	439/539	25	Helmke
Carbon Cycle	Geology	101	150	Vann/Hall
Humans & the Environment	Health	102	75	Herbert
Water Quality & Health	Health	462	15	Shorten
Water Quality & Health	Health	533	10	Shorten
Science, Technology & Environmental Systems	Honors	314	35	Welch/Fritschle
Introduction to Ethics	Philosophy	180		Woolfrey
Democracy & Education	Professional & Secondary Ed	300 (2 sections)	50	Morgan
Military Science	USSSS	101,102,201,202,301,302 (consolidated lab)	25	Niles & Purdy