ARS Long-term Agro-Ecosystem Research Network; Response to Request for Information RFI

Candidate Site: ARCHBOLD including **ARCHBOLD BIOLOGICAL STATION,** the **MacARTHUR AGRO-ECOLOGY RESEARCH CENTER** and a partnership with the University of Florida Institute of Food and Agricultural Sciences IFAS **Range Cattle Research and Education Center UF RCREC**

Submitters: Hilary Swain−Executive Director Archbold, Elizabeth Boughton−Archbold-MacArthur Agro-ecology Research Center Research Director; and Maria Silveira−University of Florida, RCREC.

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INTRODUCTION

Archbold Expeditions (Archbold), an independent not-for-profit organization established in south-central Florida in 1941, is an internationally recognized center for research, conservation, and education (Swain 1998, Lohrer and Swain 2007, www.archbold-station.org). Staff, visiting investigators, and students conduct research primarily focused on the environments of Lake Wales Ridge and the Northern Everglades (Fig 1). Archbold is known world-wide for long-term research–datasets extend back more than 80 years; areas of research strength are ecology, conservation biology, agro-ecology, and restoration ecology. More than 1,979 scientific publications have been produced by staff and visiting scientists. Archbold is used heavily for education; since 1990 this includes research training for 400 graduate and post-baccalaureate research internships, hundreds of students with college classes; more than 50,000 K-12 students; and extensive public outreach. Archbold research guides land management and conservation for protected areas, working ranches, and restoration sites throughout Florida, and globally. For this LTAR Archbold is partnering with the UF Range Cattle Research and Education Center RCREC, a neighboring center which conducts research for the Florida cattle industry with a similar focus on sustainable grazing lands; UF RCREC is specifically added to include native range landscape to this LTAR. The proposed LTAR experiences a subtropical climate with average annual precipitation of 1650mm (>65% in Jun-Oct wet season) and average minimum and maximum daily temperatures of 16.7 and 28.2^{o}C, respectively.


ARCHBOLD-MAERC

This proposed LTAR site is to be based at Archbold's three research sites (1-3), totaling nearly 9,000 ha, and (4) at the nearby 1,200 ha UF RCREC. Field research for LTAR will be centered largely at (1) Archbold's **MacArthur Agro-ecology Research Center MAERC**, a 4,251-ha 3,000-head commercial cattle ranch 8 miles east of the Station on a long-term lease (1988-) to Archbold from the John D. and Catherine T. MacArthur Foundation. Additional work will be conducted at two other sites owned by Archbold (2) the **Archbold Reserve (Reserve),** a 1,476-ha restoration site and former cattle ranch adjacent to the Station and (3) **Archbold Biological Station (Station),** a 2100-ha globally threatened scrub preserve on the Florida scrub ecosystem of the Lake Wales Ridge LWR. The fourth site (4) is the University of Florida **UF RCREC,** 30 miles to the west (Fig. 1 inset). The proposal also draws from Archbold research sites dispersed on agricultural and conservation lands throughout the Northern Everglades (yellow dots, Fig. 1) The primary focus of this LTAR is subtropical humid grasslands, providing a south-east anchor for continental-scale cross-site research with grazing lands in the LTAR network from North Dakota to Jornada in the west, to planted pastures of the eastern USA. In addition to research on grazing lands, decades of ecological research by Archbold on the LWR (Fig 1) serves as a benchmark for comparing ecosystem services from agricultural lands, primarily citrus groves, surrounding the Station/Reserve.

Archbold lies in the Northern Everglades, a pivotal watershed for understanding the role of agriculture in relation to water management, biodiversity, and a changing climate, offering comparisons for LTAR sites such as the LR watershed USDA ARS Tifton GA. The Station, Reserve, MAERC and UF RCREC provide a hydrological gradient from the LWR, to seepage slopes, to surrounding ranchlands and rivers.

Archbold and UF RCREC, both founded independently in 1941, share a mission of long-term research and education. Programs contribute to global efforts to understand, interpret, and sustain working farms and ranches while maintaining environmental values. We provide an extensive research infrastructure and large, diverse, and accessible long-term datasets spanning climate, hydrology, agricultural productivity, and ecological patterns and processes. We are well-suited to meeting the goals and demands of an LTAR site (Walbridge and Shafer 2011) and we are committed to building the vision of the LTAR network.

PRODUCTIVITY

Since 1941 a long-term, interdisciplinary research program at Archbold has been conducted by scientific staff, visiting researchers, and students at Archbold's Station, MAERC, and Reserve, and on many sites on the LWR and on grazing lands throughout the Northern Everglades watershed (Fig. 1). At Archbold MAERC, we have developed an interdisciplinary long-term agro-ecosystem research program, focused on the complex functioning of grazing lands within the watershed, informing what is required to maintain this landscape as environmentally, economically, and socially sustainable. UF RCREC (Fig. 1 inset) conducts research for the cattle industry in south central Florida with a similar focus on sustainable grazing lands. Archbold MAERC and UF RCREC are both working cattle ranches, serving as a research platform on which to employ the methods and insights of multiple disciplines, taking observational, experimental, and modeling approaches to collect, analyze, and synthesize long-term data from a common spatial setting. We offer the opportunity to examine the grand challenges in environmental science on real-world commercial landscapes. More than 1,979 publications have stemmed from research conducted at Archbold (144 from MAERC) including 174 PhD and MS dissertations and theses, and more than 300 undergraduate research projects completed. During the past 5 years the faculty at UF RCREC produced over 504 publications (including extension and unrefereed pubs) related to grazing land management and natural resources conservation. During the same period (2008-2012), 20 graduate students (MS, PhD) and more than 40 undergraduate students were associated with the programs at the UF RCREC.

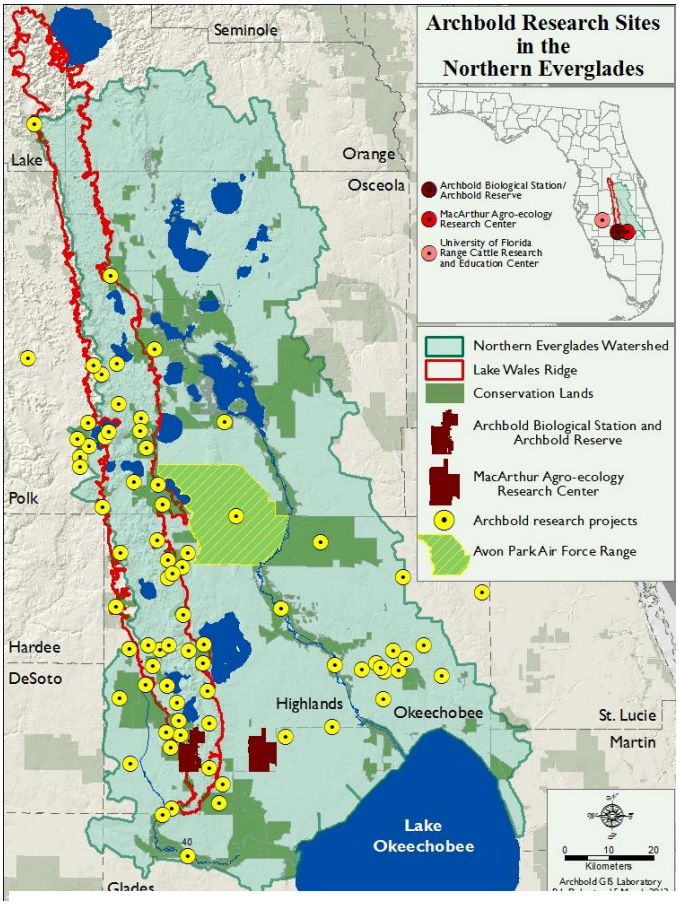


Fig 1. Location of Station, MAERC, and Reserve (dark red shapes) and recent Archbold research sites (yellow dots) on the LWR and throughout the N. Everglades watershed. Inset−location of UF RCREC, 30 miles west of Archbold.

Three examples of recent projects illustrate the types of ongoing research being conducted in relation to USDA's four goals of sustainability (USDA 2011)−meeting human needs, enhancing environmental services, maintaining viable agriculture, and enriching life for ranchers/farmers.

#1: Developing Payment for Environmental Services Programs

Study focused on the emerging conservation tool of payment for ecosystem services (PES). MAERC/UF scientists worked with ranchers, conservationists, and policy makers in the Northern Everglades to design, field-test, document, and evaluate one of the first truly market-based PES water programs in the country. Ranchers are paid to provide water storage and remove nutrients to meet public water needs. USDA CIG funding enabled studies of 7 water retention projects and 1 nutrient removal project on 8 ranches. Average annual water retention was 600 ha-m (5,000 acre-feet); one site removed 12 MT of P over 3 years. This lead to an interdisciplinary EPA STAR-funded study to assess trade-offs among ecosystem services (e.g. hydrology vs invasives/native plants/forage) integrated with a decision support tool to enable managers to evaluate payments.

#2: Source or sink? Greenhouse gas emissions on a subtropical ranch

Standard GHG accounting and 11 years of financial data (Kohmann et al 2011) documented emissions from MAERC's cattle operation of 11,545 MT of CO_2eq/yr with enteric fermentation responsible for 60%. Emissions were offset by an estimated 17,812 MT/yr sequestered using grazed Bahia grass pasture values. A new experiment to refine on-site measurements of C sequestration and to measure methane fluxes (with USDA ARS USDA-ARS Global Change Unit). This includes 5 eddy flux towers with methane sensors established in 2012 in 2 improved and 2 unimproved pastures (w&w/out cows) plus 1 wetland. Tower and soil chamber data will provide full GHG accounting for a working ranch and differentiate among methane and CO_2 from cattle, pastures, and wetlands. This has policy implications for cattle GHG management and carbon PES payments.

#3: Plant productivity & diversity in response to grazing and fire

Three separate studies using long-term plots and an experimental approach all show subtropical grasslands and seasonal wetlands released from grazing are invaded by shrubs. Season of fire also can alter vegetation composition. 1) Summer-burning promotes a diversity of plants, 2) Summer-burning reduces shrubs, and 3) Winter-burning promotes some shrubs. Over 6 years, average aboveground net primary productivity was 967 g/m^2. Grasses contributed 62% of ANPP in winter burns, 49% in summer burns, and 35% in unburned plots. Forbs were 1% of ANPP in winter burns, 31% of summer burns, and 13% of unburned plots. *Eupatorium capillifolium*, a native shrub, made up 4% of ANPP in winter burns, 2% in summer burns, and 60% in unburned plots. These results inform management and restoration to sustain both diversity and forage production.

A conceptual model (Fig. 2) of the management system provides a framework for integrating research. Major external factors (solid green) and internal transfers among physical/biological systems (black) drive three ecosystem services of public significance (red). Dashed green lines illustrate feedbacks from ecosystem services to management decisions and the socio-economic environment.

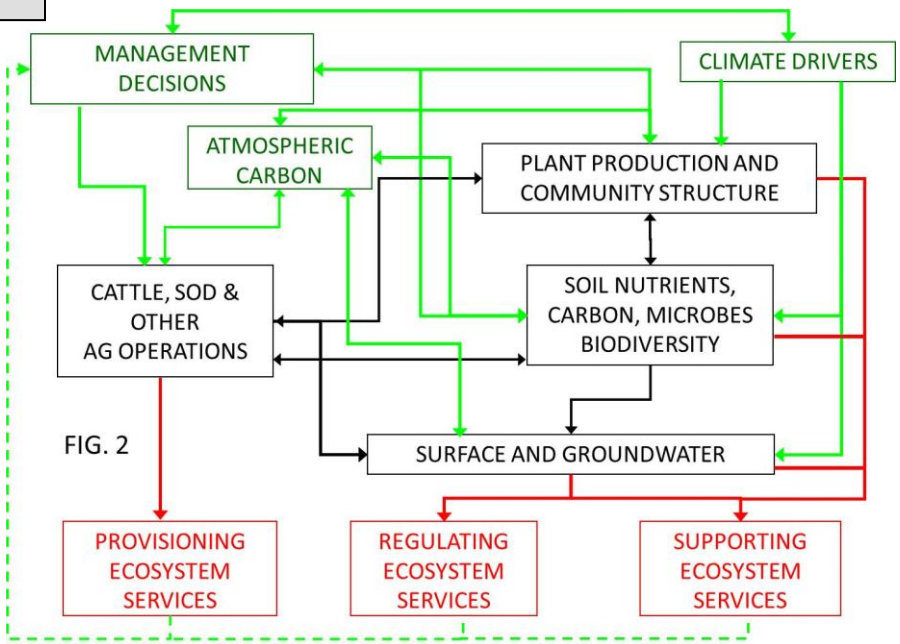


FIG. 2

Ten recent papers reflect collaboration and the broad nature of our interdisciplinary research (Table 1). They illustrate some of the relationships described in Fig. 2 including research addressing: ecological factors (plant production[1], biodiversity[2,3], hydrology[4,5], and soil nutrients[6]); climate and atmospheric (CO_2 and CH_4) drivers[7]; management decisions as controlled by economic factors[8] (production, financial performance, external market); and public policy[9] (e.g. regulatory environment). We use relationships to forecast future trends and evaluate alternative scenarios[10]. Subscripts correspond to numbers below.

TABLE 1. Selected Bibliography
1.Arthington, J.D., F.M. Roka, J.J. Mullahey, S.W. Coleman, L.O. Lollis, R.M. Muchovej, and D. Hitchock. 2007. Integrating ranch forage production, cattle performance, and economics in ranch management systems for southern Florida. Rangeland Ecology and Management 60:12-18.
2.Boughton, E.H., P.J. Bohlen, and C. Steele. 2012. Season of fire and nutrient enrichment affect plant community dynamics in subtropical semi-natural grasslands released from agriculture. Biological Conservation 158:239-247.
3.Willcox, E.V., G.W. Tanner, W.M. Giuliano, and R. McSorley. 2010. Avian community response to grazing intensity on monoculture and mixed Florida pastures. Rangeland Ecol. & Manage. 63:203-222.
4.Bohlen, P.J., and O. R. Villapando. 2011. Controlling runoff from subtropical pastures has differential effects on Nitrogen and Phosphorus loads. J. Env. Qual. 40:989-998.—
5.Capece, J. C., K. L. Campbell, P. J. Bohlen, D. A. Graetz, and K. M. Portier. 2007. Soil phosphorus, cattle stocking rates, and water quality in Subtropical pastures in Florida, USA. Rangeland Ecology and Management 60:19-30.
6.Tweel, A.W. and P.J. Bohlen. 2008. Influence of soft rush (*Juncus effusus*) on phosphorus flux in grazed seasonal wetlands. Ecological Engineering 33:242-251
7.Kohmann, M. M., C. W. Fraisse, C. C. Clifford, and P. J. Bohlen. 2011. The carbon footprint for Florida beef cattle production systems: A case study with Buck Island Ranch. Florida Cattleman and Livestock Journal 75(6):64, 66-68.
8.Bohlen, P. J., and H. M. Swain. 2009. Conceptual model for integrating ecological and economic sustainability in agroecosystems: An example from subtropical grazing lands. Pages 235-257 in P. J. Bohlen and G. House, editors. Sustainable Agroecosystem Management: Integrating ecology, economics, and society. CRC Press, Boca Raton, FL
9.Bohlen, P.J., S. Lynch, L. Shabman, M. Clark, S. Shukla, and H. Swain. 2009. Paying for environmental services from agricultural land: An example from the Northern Everglades. Frontiers in Ecology and Environment 7:46-55
10..Zhang, J., J.G. Hiscock, A.B. Bottcher, B.M. Jacobson, and P.J. Bohlen. 2006. Modeling phosphorus load reductions of agricultural water management practices on a beef cattle ranch. ASAE (Amer. Soc. Agricul. Biol. Engineers) Annual Meeting, Paper No. 062010, 12 pages.

For brevity the researchers presented here (Table 2) are limited to the 13 individuals from 5 institutions that have already collaborated extensively on agro-ecosystem research on the proposed LTAR sites. It does not include new collaborations or other Archbold staff, visiting scientists, and collaborating institutions that are relevant for this proposed LTAR; it is not possible to include them all in Table 2.

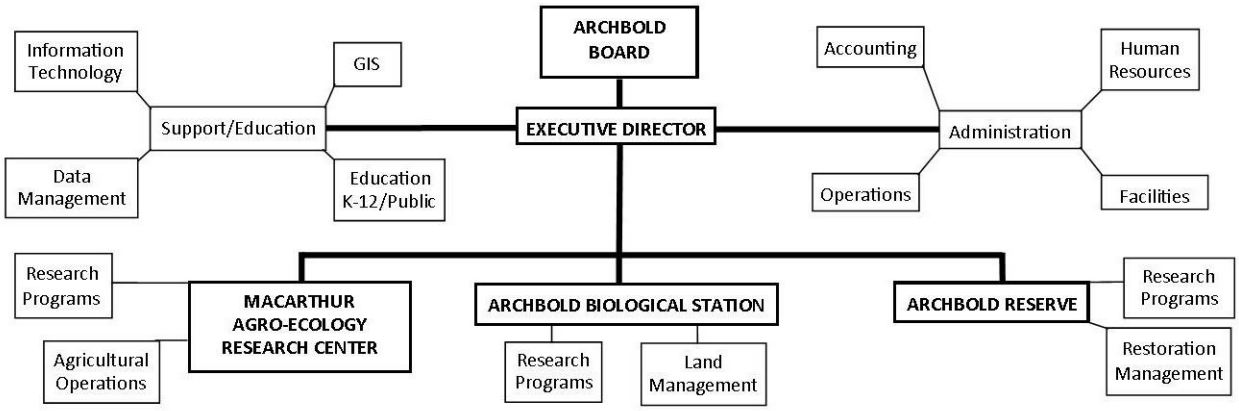
TABLE. 2. Researchers and recent productivity. [1a]University of Florida RCREC , [1b]University of Florida Gainesville, [2]University of Central Florida, [3]Archbold, [4]Trinity College, [5] Cornell University.

Name/Institution	Area of Expertise	# of years assoc. w/ Archbold	Publications 2008-2012 (journals/book chap/extension or non-refereed)	# refereed publications 2008-12
John Arthington[1a]	Animal physiologist	15	37/0/66	37
Patrick J. Bohlen[2]	Ecosystem ecologist	15	8/2/4	8

Elizabeth H. Boughton[3]	Plant ecologist	7	6/1/3	7
Raoul K. Boughton[3]	Disease ecologist/physiologist	2	13/0/2	13
Clyde Fraisse[1b]	Agroclimatology; soil and water engineering	8	17/0/13	17
Greg Kiker[1b]	Ecological, hydrological, decision support modeling DSS	8	22/5/6	27
Joan Morrison[4]	Ornithologist	24	17/0/0	17
Pedro Quintana-Ascencio[2]	Ecological modeler/Statistician	7	27/0/0	27
Brent Sellers[1]	Weed Scientist	5	31/0/164	31
Sanjay Shukla[1]	Hydrologist/Engineer	8	12/0/10	12
Maria Silveira[1a]	Soil scientist	5	34/0/40	34
Jed Sparks[5]	Ecosystem ecologist	2	32/2/0	34
Hilary Swain[3]	Conservation biologist	17	15/5/3	15
Joao Vendramini[1a]	Agronomist	5	32/0/26	32

INFRASTRUCTURE CAPACITY

Archbold employs about 50 personnel, of whom 60% are science staff, education and technical support, and 3 research divisions (Station, MAERC, Reserve). Other staff includes administrative support (N=7) ranch operations, land management, maintenance and housekeeping (N=11) (Fig 3).



Administrative and Research Support:

Archbold Biological Station Research Center

Headquarters and Offices: Archbold offices, facilities, and equipment are located primarily at the **Station**. The 1,394 m^2 reinforced poured concrete Research Center (Fig 4) encompasses offices for administration plus seven laboratories and offices for PIs, Post Docs/Research Assistants. The Library has holdings of more than 200 journals and 7,000 books. Reference collections (>230,000 specimens) include a herbarium, arthropod, wet collection, birds, and mammals. The 300m^2 Annex houses the Geographic

Information System (GIS) Laboratory, Land Manager, offices, wet collections, meeting room, and a 60-seat auditorium. The 148 m^2 Rand Building accommodates administrative staff. The Station has its own generator, water treatment plant, and large Maintenance Shop. **Archbold MAERC** has a 334 m^2 Headquarters Building with four offices, a kitchen, and meeting room for ~30. There is a 420m^2 steel barn, cattle pens, and numerous smaller barns. Data management, collections, GIS lab, meeting rooms, and administrative support are provided at the Station. The **Archbold Reserve** adjacent to the Station facilities has limited facilities– two simple pole barns.

UF RCREC offers office space and housing for students, laboratory, library, meeting rooms, and cattle handling facilities. Most facilities are new, or recently renovated, including new laboratory space and facilities for sample (soil, forage, water) handling and processing. In addition to the physical facilities, the UF RCREC has a dedicated support staff that assists with all facets of work and training students

Laboratories: **Station** laboratories are Avian Ecology, Plant Ecology, Entomology, Herpetology/ Restoration Ecology, Disease Ecology, and two multi-user labs (for resident scientists and visitors) with general-purpose 60 m^2 Chemistry lab and 44 m^2 Multi-User Lab. The latter have fume hood, de-i water, Olympus BX60 compound microscope, Olympus SZX12 stereoscopic microscope, multiple workstations, oven/muffle furnace, analytical and top-loading balances, germinator, growth chamber, -80 freezer, and other smaller equipment. **MAERC** has a Wet Lab and Ecosystem Lab with drying ovens, Spex CertiPrep 8000-D Mixer Mill,Tekmar A-10 analytical mill, Wily Mill, Thermolyne Muffle Furnace, µ Quant Spectrophotometer, Autoclave EZ9 Steam Sterilizer, two centrifuges, Comaerc Z Heating Plate, IsoTemp Oven, Titer Plate Shaker, and Radioisotope Gas Chromatograph, in addition to microscopes and balances. At **UF RCREC** the laboratories are fully equipped including a Flash EA 1112 CN combustion analyzer, Seal AQ2 discrete analyzer, Perkin Elmer Clarus 480 gas chromatograph, Ankom 2000 Fiber Analyzer and Daisy II 200-220 Incubator for forage quality analysis, analytical balances and microbalance, fume hood space, digestion block and hot plates for acid digestion, and oven and muffle furnace.

Housing: the Station can host nearly 100 overnight visitors. An 800 m^2 Lodge, opened in 2012, accommodates up to 41 persons for group visits. In addition there are seven cottages with kitchens to host up to 40 longer-term visitors. The Station dorms accommodate 15 students. There is a kitchen and dining room. The Lodge and one cottage are wheelchair accessible. At MAERC there are 10 cottages for staff and 4 cottages, with up to 32 beds, for visiting scientists. Graduate student housing is available and free at UF RCREC for students enrolled in research.

Education and Outreach: research students at Archbold are mentored within respective research programs. Faculty and visiting college classes from around the world are hosted in a 20-seat classroom in the Research Center. The new 830 m^2 Learning Center at the Station, opened in 2012, has space dedicated to K-12 education, interpretive displays and exhibits for public education; conference, training workshop, and meeting facilities for up to 140 people. Facilities are wheelchair accessible. MAERC hosts group meetings for up to 38 and offers a swamp buggy public tour. UF RCREC offers a number of education and outreach activities. During the past 5 years, these programs include summer Youth Field Days with more than 1,000 K-12 students attendees, Weed Field Days (553 participants), and RCREC Field Days (800 participants).

Field Infrastructure (see also landscape section): Archbold **Station** is a 2,100-ha globally threatened scrub preserve; Archbold **MAERC**, located 12 km east of the Station, is a research facility operated on a private 4,251-ha ranch (leased from the MacArthur Foundation). MAERC is a 3,000-head, beef cow-calf operation (among the top 20 in Florida in herd size) also producing sod, a hunt lease, and minor harvesting of cabbage palms. Agricultural operations are managed at a full commercial scale, representative of the region. The Archbold **Reserve** is a 1,476-ha former cattle ranch, still supporting 550 head, with four major USDA Wetland Reserve Program WRP sites under restoration. All Archbold habitats are available for experimental manipulation. The **UF RCREC** has 600-ha of native rangeland (not available at MAERC), 600-ha of developed pastures, and 1,200 head of cattle.

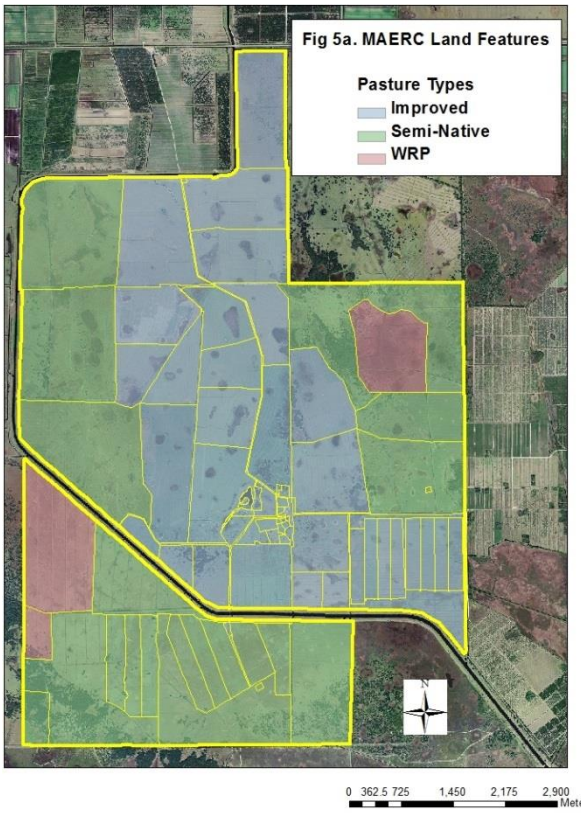
Vehicles: for access to the field the Archbold **Station** fleet has 15 4-wheel drive pickups, 18 ATVs, as well as 3 station wagons, 3 fire engines, a swamp buggy, UTV, tractor, and a 4m Boston Whaler. **MAERC** has 8 4-wheel drive pickups, 2 swamp buggies, 3 tractors and other heavy equipment, and 4 ATVs/ UTVs. UF **RCREC** field equipment includes tractors, sprayers, mowers, and a forage harvester.

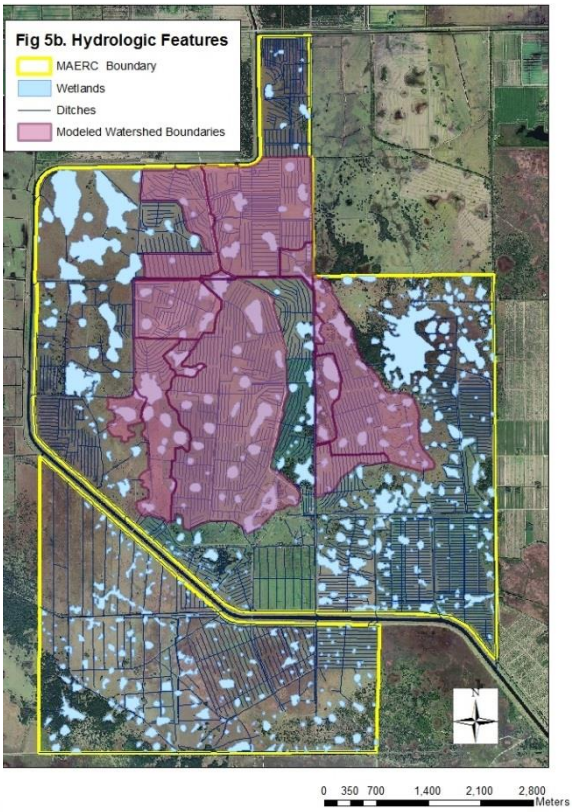
IT Support: http://www.archbold-station.org/station/html/datapub/support/it.html**.** A gigabit fiber optic FO backbone extends to all departments of **Archbold** and integrates and promotes local and Internet access and wireless technologies into Archbold activities. A Computer Center includes the System Administrator's office, repair room, server room, and storage room. Computing services are predominantly Microsoft operating systems. The Archbold LAN connects over 60 computers and peripherals, including 15 at MAERC and serves about 50 resident users. A fiber optic backbone connects workstations to the main Server Room which includes 7 servers providing essential services and hardware including Mail, SQL, GIS, WWW and FTP services, Web Filtering and Virus protection, Netgear switches, a Cisco router and firewall, and network attached storage. Internet connectivity is via four multiplexed T1 lines. Archbold's 5-ha campus is served by wireless Access Points connected to the FO backbone and MAERC has wireless access at the HQ building. Remote datastreams are received via a wireless network (~10 mile omnidirectional) using RTMCpro. A single segment LAN at MAERC is connected to the Internet via T1 and virtually connected to the Station's LAN via point to point VPN. Archbold supports a GIS Administrator responsible for spatial datasets and training in GIS. Archbold's Data Manager implements a metadata catalogue ARCHDATA using Ecological Metadata Language (EML) developed by NCEAS. Staff is migrating metadata from numerous monitoring, research and spatial datasets into ARCHDATA. Vega models manage weather, hydrological, and other datasets. Metadata and data are served from the web using MS SQL and Cold Fusion via http://www.archbold-station.org/station/data/index.cfm . ftp://archbold-station.org also provides data access. Webconferences are disseminated via the Internet. At **UF RCREC** computer networking is available for students and staff use and includes a variety of services such as access to scientific literature via Internet, library facilities, and computer software for data storage, process, and analysis.

Landscape: Archbold Station is comprised of globally imperiled habitats, including oak and rosemary scrubs, sandhills, pine flatwoods, cutthroat seeps, and seasonal wetlands. The adjacent **Archbold Reserve** contains scrub, flatwoods, seepage slopes, and 500 ha of wetland restoration as well as extensive pastures. There are 200 burn units at the Station/Reserve with a spatially explicit 40-year fire history (GIS). These two properties are surrounded by LWR orange groves to the north-east, and rangeland to the west-south. Descriptions of the Station and Reserve including fire and land management and the extensive sensor network (4 weather stations, wells, lake buoy, atmospheric sampling) are at www.archbold-station.org.

Research is also conducted at more than 30 off-site properties along the LWR including state forests, parks, and wildlife management areas (Fig. 1) all surrounded by agriculture, mostly orange groves. Archbold's has operated a 20-year research program at the Avon Park Air Force Range (Fig. 1) where military operations are conducted in a matrix of natural lands, agricultural, and forestry operations.

We focus here on the landscape of **Archbold MAERC** as it is most relevant for LTAR. LIDAR imagery (NSF NCALM 2005) illustrates minimal topography from 11.3 mamsl (north) to 8.1 mamsl (south) with poor natural drainage and a high wet-season groundwater table. There are 63 fenced grassland units, 43% of the property (4,528 ha) is improved Bahia pasture with extensive ditching, intermittently fertilized with N (50kg_ ha_1), and historically fertilized annually with P until 1987 (Fig 5a). Semi-native pastures (47% (4,891 ha) are less drained, without fertilization, and dominated by C4 bunch grasses such as *Andropogon virginicus* var. *virginicus*, *A. virginicus* var. *glaucopsis*, *A. glomeratus*, and *Panicum longifolium*. There are more than 600 wetlands and 643 km of ditches (Fig 5b), and 250 hardwood hammocks. Soils are poorly drained fine sands composed of fine sand (hyperthermic alfisols and spodosols).

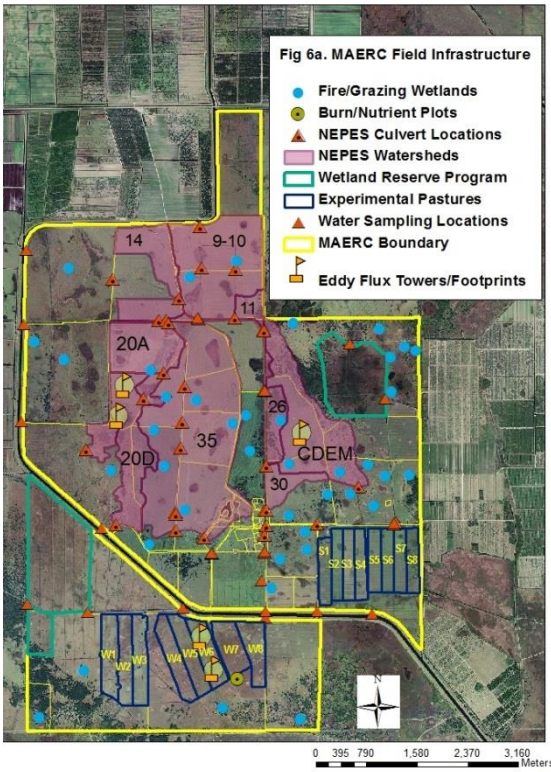


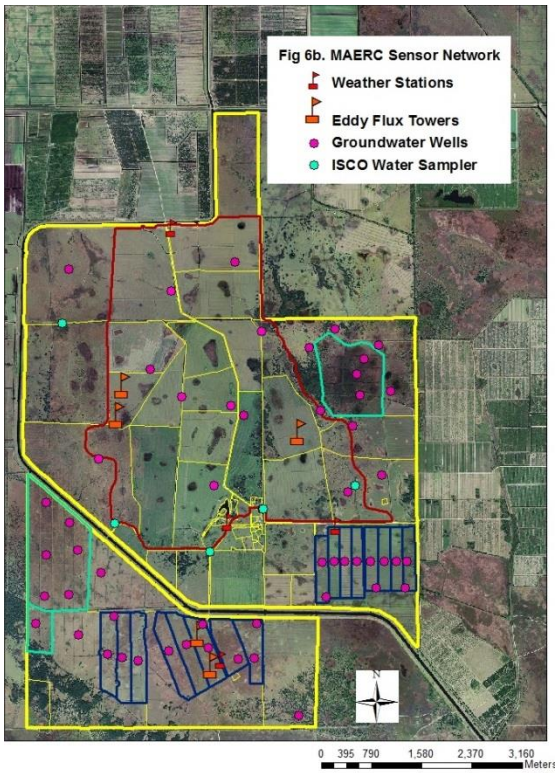


<u>Capacity for field experimentation.</u> **Archbold MAERC** has multiple sites dedicated for long-term experiments (Fig 6a). These are operated while maintaining the feasibility of a commercial-scale ranch.

1. 16 experimental pastures (8 improved, 20-ha each, S1-S8) and 8 unimproved (32-ha each, W1-W8) designed with flumes for surface water flow and sampling (some flumes need renovation).
2. 40 wetlands (blue dots, Fig 6a) with full factorial cross pasture (improved, unimproved) x grazing (fenced, grazed) x fire (burn, no burn) experimental design (5 wetlands in each of the 8 treatments).
3. 16 fire (winter/summer/unburned) nutrient addition (N/P/N+P/control) plots (yellow circle+black dot)
4. Two wetland restoration sites with 32 transects with/without grazing (exclosures).
5. Five watershed basins monitored, 1 with MIKE SHE model as part of our research program.

6. 4 pastures (improved, unimproved) x grazing (fenced, grazed) and one wetland for carbon flux experiment in cooperation with Carl Bernacchi, USDA-ARS Global Change & Photosynthesis Research Unit, Urbana, IL and Jed Sparks (Cornell University) (orange flag +green circle).
7. In addition there is a dense sensor network (Fig 6b) including 4 weather stations, 5 flux towers, 32 groundwater wells, and many water sampling locations.





UFRCREC

Five range sites (areas 1-5) at UF RCREC (Fig. 7), consisting of mixture of rangeland and forest ecological communities, have been managed by the University of Florida since 1941 with a 50-year record of burning. The rangeland includes South Florida Flatwoods (grass-shrubland to pine savanna), Freshwater Marsh and Ponds (hydric soils with herbaceous plant community and few woody species), and Slough (wet prairie). The forested communities range from xeric to hydric communities - Sand Pine Scrub, Upland Hardwood Hammocks, Wetland Hardwood Hammocks, and Swamp Hardwoods. UF RCREC is characterized by a homogeneous slope (<5%).

Fig. 7 Aerial image of the 5 range sites at UF RCREC

DATA RICHNESS

Archbold has amassed a vast legacy of long-term monitoring and research datasets dating back to 1931. For LTAR some of the most relevant **Station** datasets are meteorological (daily temperature and rainfall since 1931) and sediment paleo records for Lake Annie (48,000 YBP), one of the most important climate reference sites in the eastern USA. At Archbold **MAERC** systematic data collection started in 1994 including long-term experimental and observational ecological data as well as agricultural operations and performance (Table 3). MAERC research harnesses these multi-disciplinary data to decipher environmental phenomena in relation to economic factors; this breadth of data has strong potential for cross-site LTAR collaboration and synthesis. Existing water balance and carbon flux research at the Station and MAERC argues for Archbold's capacity to integrate across soil, water, and air processes. Archbold MAERC and UF RCREC maintain agricultural operations databases to document movements of cattle, animal use days, feed, fertilization, prescribed burning, pasture management, etc. These data have been recorded systematically at MAERC since the 1990s and earlier at RCREC. At MAERC we track all 3,000 individually marked (EID) cows in the herd including health, weight, pregnancy, pharmaceutical activities, and body condition every time cattle are worked through the pens. A financial database (Standardized Performance Analysis SPA) has been maintained by MAERC since 1992 to document annual production and financials. There is full access to UF RCREC and MAERC accounting data for histories of revenues and expenditures. MAERC Ranch Manager, Gene Lollis and the Archbold CFO work closely with scientists to provide operational and financial data for research.

Table 3. Major categories of research data relevant to LTAR. This is a subset of Archbold and UF RCREC projects. For brevity Table 3 does not include Archbold Station or Reserve long-term datasets.

Project/Dataset	*Timespan*	*Description*
ARCHBOLD MAERC SPATIAL DATA		
MAERC spatial data library	1992 – On- going/constantly updated Every decade since1940 2005	GIS shapefiles for soils, wetlands, vegetation, pastures, property boundary, structures, ditches, research and monitoring sites, etc. Geo-rectified aerial photos (multiple years). LIDAR coverage (20 cm resolution).
ARCHBOLD MAERC CLIMATE DATA		
MAERC – 4 stations Archbold NWS and NOAA CRN station	1992–On-going 1931–On-going 2008–On-going	Hourly temp, precip, BP, rH, wind, soils etc. Daily (since 1931) for precipitation & temperature. Hourly since start 2008 for temp, precip, BP, rH, wind direction/ speed, soils temp/moisture, etc.
ARCHBOLD MAERC HYDROLOGICAL DATA		
MAERC Groundwater	2000 (4), 2007-Ongoing	32 wells.
Flow/nutrient loads	1998–2003: 16 sites 200 –2006 : 8/16 sites 2007-2011 five basins 1 basin-Ongoing	Flow/nutrient loads 16 expt pastures (see ecology). Flow/nutrient loads 8 expt winter pastures. Flow/nutrient loads 5 basins. Flow/nutrient loads basin 35.
PES - water retention P reduction	2007–On-going	FRESP/ NEPES. MAERC, 23off site monitoring locations; water level, rainfall, water quality.
On ranch ditches and Harney Pond Canal	1998–On-going	Monthly data collection: Total P; Nitrate; Total N;NH_4; DO; pH; conductivity.

ARCHBOLD MAERC ECOLOGICAL DATA		
40 experimental wetlands with grazing and fire treatments	Oct 2006–On-going	Plant composition /Biomass. Wetland insects /vertebrates. Soil/Water nutrients; staff gauges.
Season of **fire** and **nutrient** addition	2002–On-going	Plant ANPP/composition/N mineralization/ microbial biomass/plant tissue concentrations.
USDA **Wetland Reserve Program** vegetation transects	2003,2012–On-going	Plant composition responses to wetland restoration in relation to grazing.
16 **experimental pastures**- 2xland use, 4x stocking density,2x water treatments	1998–some measures still on-going	Quarterly vegetation transects, with grazing exclosures/soil sampling array/ bird census/ cattle movements w/GPS collars. See also hydrology section.
Trade-offs in **wetland ecosystem services**	2010–2014	8 ranch wetlands plus 7 more off-site to assess PES water program on ranchlands; Decision support tool; hydro-ecological modeling
Eddy flux towers, carbon soil sites, NO_2, CH_4 chamber work	2011–On-going	In cooperation with USDA-ARS, Global Change & Photosynthesis Research Unit, Urbana, IL. Eddy flux towers (5) w/ C, H_20 and CH_4 sensors.
Caracara, Barred Owls Red-shouldered Hawks,	1992–On-going	On-site and surrounding region. Population biology and reproductive success.
Overwintering **birds**	1996–2002	Point count surveys.
Wading birds	1990–2004	Includes 11 years of 20km ditch transect data.
ARCHBOLD MAERC AGRICULTURE OPERATIONS/PRODUCTION DATA		
Agricultural Operations – pasture database	1995–On-going	Pasture operations – animal use days, burning, fertilization, feed delivered, chopping, sod harvesting etc.
Agricultural Production Measures – individual cattle database and SPA	1992–On-going	Cattle performance includes herd size and age structure, body condition, #s exposed cows. pregnancy %, #s weaned calves; vet care
Key Marketing and Financial Measures SPA	1992–On-going	Financial; assets, inventory, costs of feed/fertilizer/ labor, Cost/Cow, Unit cost/weaned calf.
UF RCREC: NATIVE RANGE and PASTURES		
Invasive plants	2008–On-going	Plant composition, biomass, chemical applications.
Soil carbon,CO2 flux Ecosystem C	2011–On-going 2012– On-going	Soil carbon,CO2 flux. above- below-ground C biomass, soil CO2 efflux, soil temp and moisture.
Cattle/calf performance on rangelands	1984–1986 1996–2000	Botanical diet composition, steer weight, Cow weight, pregnancy rates, calf weight.
Plant composition in relation to: fertilization deferment from grazing & shrub control/fire	 1994–1996 1992–1994 1984–1986	 Plant diversity, density, biomass. Plant diversity, density, biomass. Plant diversity, density, biomass.
Economic evaluation of range management	50 year record for some parameters	Budget and financial data on range practices such as tandem-chopping, rotational grazing, etc.

DATA AVAILABILITY

Archbold has extensive experience managing long-term ecological research and environmental monitoring data. Archbold works with NSF's LTER data managers, collaborated with NSF's Knowledge and Distributed Information Project, and is a member of the GLEON Global Lake Ecological Observatory Network. Director (Hilary Swain) serves on the National Ecological Observatory Network NEON Board.

Data Collection. Archbold and UF RCREC have a wide range of data collection procedures for research and monitoring. For many datasets, data collection and handling are guided by project specific Standard Operating Procedures (SOPs), which document equipment, datasheets, and detailed field and data protocols. Project Quality Assurance Managers (PI or research assistant) are responsible for training of RAs and students. Many sensor data are streaming wirelessly or via cellular.

Data Entry and QAQC. Initial QAQC for automated sensor data is by flagging using range, persistence and step tests. Manual data are entered into Access databases or Excel spreadsheets, and checked against original data sheets, usually by two people. Further QAQC occurs between sampling sessions or monthly/annually for automated data to calculate means, min and max , frequency distributions, bivariate plots, and crosstabs to flag out-of-range or unlikely values. Potential errors are resolved by logical rules, reference to datasheets, or return visits to plots. Additional QAQC is done as analyses are conducted.

Data Security and Archival. Primary data are stored centrally on Archbold's modern network (see IT infrastructure). A fiber optic backbone connects Archbold workstations to the main Server Room which includes 7 servers providing essential services and hardware including Mail, SQL, GIS, WWW and FTP services, Web Filtering and Virus protection, Netgear switches, a Cisco router and firewall, and network attached storage. Network files are saved to automated backup tapes, daily and monthly. There is an annual complete system archive. Spatial data (ArcGIS shapefiles) are managed centrally on a dedicated GIS server, with the same network backup protocols. Data from projects are also backed up off-site.

Metadata. Metadata for research projects, are entered into an MS Access database called ARCHDATA, based on Mitchener 1997 and earlier versions of MORPHO. MAERC-related projects have at least level 1 metadata; a basic cataloguing including project title, abstract, PI information, and general approach. Projects with data posted on the web have level 2 or 3 metadata entered including information on: field and analytical methods; UTM coordinates; associated researchers (collaborators, post-docs, students); funding source; collaborating organizations; keywords (based on NASA/Global Change Master Directory controlled vocabulary); taxon; publications; and associated data tables including attribute tables (name, definition, measurement, unit format, QAQC, etc) and methods tables (sampling, accuracy, coverage, field methods, instrumentation, etc.). Metadata are accessed via www.archbold-station.org using Cold Fusion for querying and downloading metadata (in ARCHDATA) from an MS SQL server. Metadata are output as Ecological Metadata Language EML (an XML markup vocabulary).

Data Access. Archbold is committed to archiving data in perpetuity (policy, since 1941). The Data Access policy is posted at http://www.archbold-station.org/station/html/datapub/data/dataaccpol.html. Archbold meets all official requests for publically funded data. We are working towards the goal that all metadata will be published on-line. Select MAERC monitoring data are already available on-line or by request. Project research data are released on/before publication or, at the latest, by 7 years (whichever is earlier). Archbold staff is expected to share and publish data, as well as post data, metadata, and derived data on the Archbold web site and elsewhere. Archbold's philosophy of rigorous data management and sharing data broadly has led to many productive scientific endeavors and collaborations.

Data Publication. All publications stemming from research at MAERC are posted in Archbold's on-line searchable bibliography STABIB http://www.archbold-station.org/station/html/datapub/pub/stabib.html.

GEOGRAPHIC COVERAGE at VARIOUS SCALES and UNIQUE ELEMENTS

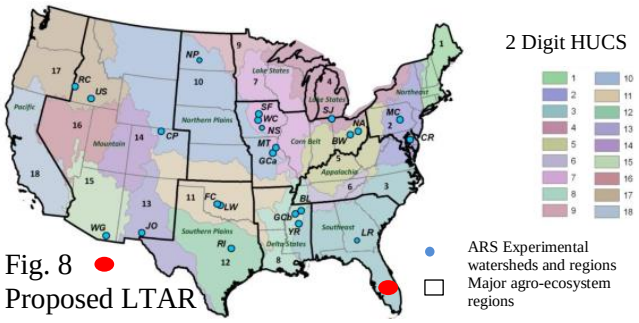


Fig. 8 Proposed LTAR

According to the FAO (FAO 2000) much of the world's grazing lands lie in the subtropics including both arid and humid subtropical grazing lands dominated by C_4 grasses. These are potentially significant sinks for GHG (Conant 2002). An Archbold LTAR will **represent subtropical humid C_4 grasslands and shrublands** within the southeastern USA (Fig. 8. Region 3 HUC, South Atlantic-Gulf) with warm wet summers and cool dry winters. The region is an important geographic endpoint for gradients of climate and climate change. Climate projections (Fig. 9, USGCRP) exhibit uncertainty for this region−downscaling shows a transition area, potentially either drier or wetter. Paleo records (>40,000 years) from Archbold's Lake Annie are key climate references for FL (e.g. Quillen et al. 2013).

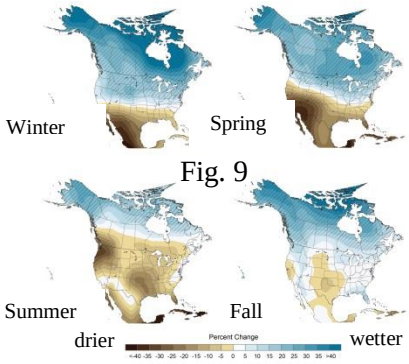


Fig. 9

Archbold lies in the Northern Everglades (HUC 03090201, Lake Okeechobee, FL, Fig. 1) a **globally critical watershed known world-wide for unique** challenges with water quality especially Phosphorus loads. Archbold research projects are conducted throughout the subbasins of the Northern Everglades watershed (Fig. 1) examining hydrology from the high sandy soils of the ridge (LWR), down the seepage slopes, to the ranches and rivers of the Northern Everglades. The native range of UF RCREC, although outside this watershed, is representative of regional hydrology and UF faculty conduct research on many Northern Everglades sites. The watershed is also an **unique international hotspot for rare and endemic species** (US FWS 1999, Turner,Wilcove and Swain 2006) especially on the LWR (location of Archbold Station/Reserve).

The proposed LTAR lies in the **NEON southeast Domain 3**. Archbold was closely involved in the design of NEON. Hilary Swain was Chair of the NEON research infrastructure committee and is a current second-term board member of NEON Inc. Ultimately Archbold was not selected as a relocatable NEON site for the first round deployment, but will be under consideration as a future relocatable site. Lake Annie, on the Station, is part of the Global Lake Ecological Observatory Network **GLEON** participating in cross site experiments, analysis and modeling with 40 lakes worldwide.

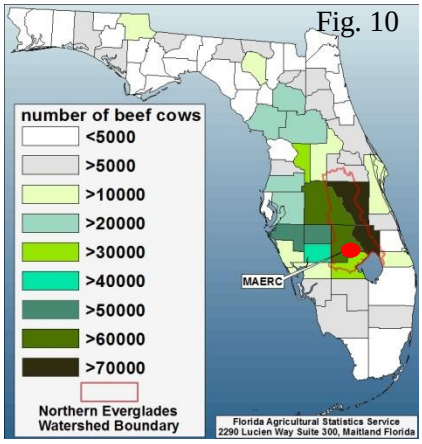


Fig. 10

There are more than a million head of beef cattle in Florida, and over 80% of them within 150 miles of the proposed LTAR (Fig. 10). The continuum from improved and semi-native pastures (Archbold MAERC) to native range (UF RCREC) with hundreds of embedded seasonal wetlands (similar to mid-western prairie potholes) will facilitate continental-scale comparisons of similar gradients in the western and eastern USA. This proposed LTAR site is uniquely positioned to contribute to theories across gradients of management intensity, climate, and hydrology at regional, national, and international geographic scales.

PARTNERSHIPS

Archbold and UF IFAS have a broad network of research, monitoring and educational/outreach partnerships relevant to this LTAR (Fig 11). Archbold repeatedly seeks opportunities to partner with networks/frameworks at regional/global scales. Meteorology data are networked with the NOAA-Climate Reference Network CRN station on-site, and National Weather Service Coop stations. UF RCREC is part of UF FAWN, a state meteorological network. Archbold participates in state monitoring networks including an ozone monitoring site, SW FL and S FL Water Management District WMD groundwater wells, and numerous water quality sampling sites for state and federal agencies (WMDs, FL DEP, and USGS). Burn data are integrated into regional databases for fire management.

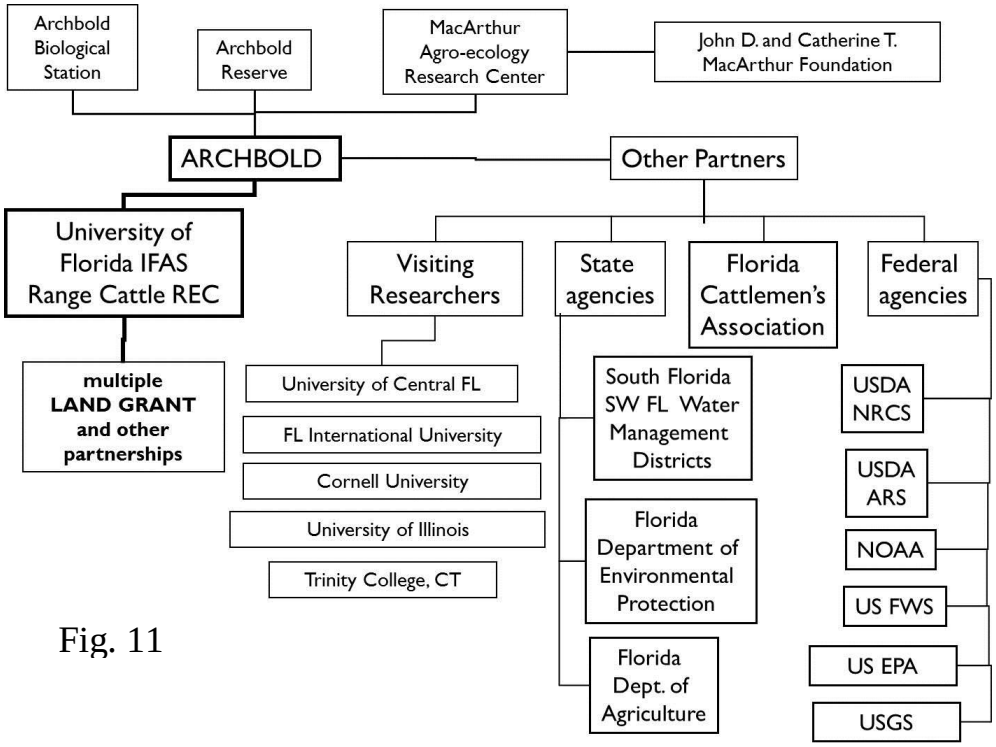


Fig. 11

Archbold and UF IFAS have innumerable research partnerships with other research institutions, some illustrated in Fig 11. This includes close ties to LTER sites such as hydrological research with Gaiser (Florida International University, PI Florida Everglades LTER) and Archbold-initiated cross-site comparisons of grazing and nutrient treatments with Konza Prairie LTER leading to a review of our 10-year study and a presentation and book chapter at the *Grasslands in a Global Context Symposium* (Boughton and Bohlen 2013). The data from the Archbold–USDA ARS research on GHGs, part of an emerging network of flux towers extending from Everglades headwaters to LTER sites in Florida Bay (Fig. 12), will serve as a critical southeastern benchmark for LTAR cross-site synthesis.

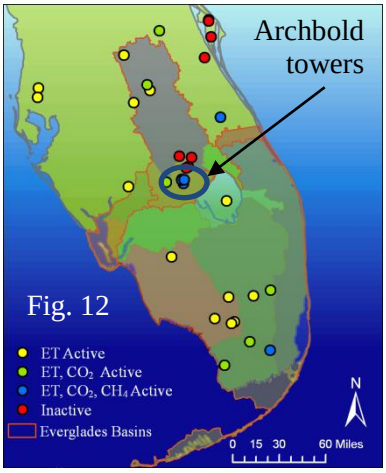


Fig. 12

For education and extension, UF IFAS and Archbold have close effective partnerships with producers such as the Florida Cattlemen's Association and the Florida Citrus Growers Association. Archbold is heralded for building coalitions between agricultural and environmental/conservation groups such as the World Wildlife Fund and The Nature Conservancy. This has led to highly innovative and nationally recognized conservation projects on working farms and ranches, such as the FRESP and NEPES Payment for Environmental Services programs.

Institutional commitment

ARCHBOLD BIOLOGICAL STATION
123 MAIN DRIVE • VENUS, FLORIDA 33960

DATE: 4/1/2013

SUBJECT: Letter of Support

TO: Long-Term Agro-Ecosystem Research Network, Steering Committee

FROM: Hilary Swain Executive Director, Archbold Expeditions

I fully endorse and support the inclusion of the Archbold Biological Station, Archbold Reserve (both owned and operated by Archbold Expeditions) and the MacArthur Agro-ecology Research Center (on a long-term lease since 1988 to Archbold from the John D. and Catherine T. MacArthur Foundation). Archbold, established in 1941, is committed to continuing its multi-decadal commitment (>70 years) to long-term ecological research. We welcome the opportunity to participate in the USDA LTAR and have demonstrated the capacity for cross-site research, and scientific publications stemming from this work. If selected Archbold is ready to assume the responsibilities of a LTAR Network Site and willing to collect the core set of LTAR data. Our Board of Trustees, scientists and support staff are absolutely committed to this effort and our collaborating scientific partners have all agreed enthusiastically to participate.

We believe that Archbold's long-term agro-ecosystem and other biological research programs together, with our capacity to integrate across soil, water, and air processes, and can make an important contribution to a network of LTAR sites. We lie in a pivotal watershed with extensive research infra-structure and large, diverse, and accessible long-term datasets spanning climate, hydrology, agricultural productivity, and ecological patterns and processes. We are well-suited to meet the goals and demands of an LTAR site (Walbridge and Shafer 2011) and are committed to building the vision of a LTAR network.

DATE: 4/1/2013

FROM: John Arthington, Center Director, University of Florida, Institute of Food and Agricultural Sciences, Range Cattle Research and Education Center (RCREC), Ona, Florida

UF UNIVERSITY of FLORIDA
IFAS
Range Cattle Research and Education Center

We fully support the consideration of Archbold's inclusion as a site of the LTAR network. If selected, the RCREC is committed to serving as an integral partner with Archbold to fulfill the LTAR mission. Owned by the State of Florida and operated by the University of Florida for over 70 years, the RCREC supports faculty programs with research efforts addressing natural resources issues and forage/livestock production practices on Florida's rangelands. Our extensive publication record in the peer-reviewed science is evidence of the productivity of these research programs. Further, each program has a Cooperative Extension outreach responsibility, which directly links our citizen stakeholders to the outcomes and impacts of our research efforts. Located a short driving distance from each other, the RCREC and Archbold share a history of productive collaboration. As an enhancement to the LTAR, our individual landscapes have complimentary features, such as extensive upland, native Florida range at the RCREC to the well-documented wetland range sites of Archbold. If selected as an LTAR site, our partnership would uniquely combine existing public and private institutional capacity into an LTAR site that will be well-suited to address the goals of the LTAR network.

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