Federal Funding Required to Meet the Science Challenges in Agriculture and Food Systems

A supplement to "A Science Roadmap for Agriculture"
(see http://www.escop.msstate.edu/draftdoc.htm**)**

Prepared by the ESCOP Budget and Legislative Committee
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I. Analysis of Current Scientific Capacity and Estimates of Future Needs

It is essential to provide policy makers with detailed recommendations on the research needed to support agriculture and food systems. This will assist them as they establish priorities for funding science for the public good. To undertake this assignment, a committee of scholars was charged by the Experiment Station Committee on Organization and Policy (ESCOP) to look forward 10 to 20 years to chart the major directions of agricultural science. The resulting science roadmap for agriculture will assist decision-makers and advocates for the research and education system, as they mobilize and plan the allocation of resources for future program areas.

The roadmap highlights seven areas where significantly enhanced and/or new research efforts will be needed to meet the challenges of the next 20 years. These challenge areas and associated objectives were used to organize the study's activities, and to report the group's findings in the resulting publication, "A Science Roadmap for Agriculture" (see http://www.escop.msstate.edu/draftdoc.htm).

The next steps involved identifying the appropriate mix of faculty expertise that is required to meet these challenges/objectives and pursuing federal budget increases to assist the Land-Grant agricultural research system in obtaining that expertise mix. To aid in estimating future expertise needed, an approximation of the current effort focused on each challenge/objective was determined using the Current Research Information System (CRIS) database on scientist years (SY) for each Field of Science (FOS) classification.

A request was then distributed to 45 directors of state agricultural experiment stations in 1862 and 1890 institutions to estimate the appropriate mix of FOS's that will be required to address each challenge/objective. Nineteen directors responded with estimates as either number of SY's or as percent of objective total for each FOS in each challenge/objective. States responded representing all regions and a range of rural and urban concentration. The data ultimately resulted in the number of SYs in each FOS that would be needed to address each challenge area.

II. Estimating the Budget Impact to Adequately Address the Seven Challenges

The analysis described above provided an estimate of additional SYs needed to meet the challenges in agriculture and food systems. However, there is also capacity in the current research establishment to contribute to meeting the challenges. This is readily apparent by examining the success rate of proposals submitted to competitive grant programs administered by the federal government and the high quality science described in proposals that do not receive funding. In the subsequent analysis, data were gathered from CSREES on the National Research Initiative (NRI) and the Initiative for the Future of Agriculture and Food Systems (IFAFS) and from HHS National Institutes of Health (NIH) on their respective rates of success in funding and the good science that was not funded due to a lack of federal dollars for research. Furthermore, the analysis provided by the experiment station directors was used to estimate the additional investment required by state, federal and non-federal funding sources to meet the seven challenges.

A. NIH and NSF success rate and capacity

Table 1 presents the estimated unfunded capacity for research in the R01, R03, R15, R21, and R33 competitive projects categories for NIH for the years 1998, 1999 and 2000. Note that in the R01 (Research Project) category, funding increased dramatically in 2000 ($177M increase). Officials at NIH in the External Research Division estimate that 50% of the funds requested through the competitive grants programs could be awarded based on quality of the science. Based on this information and data in Table 1 (taken from the NIH home page), an increase of $1.537 billion in these five categories could be utilized to support good science if the funds were appropriated by the federal government, a 69% increase over FY'00 appropriations.

Similar data for NSF are shown in Table 1a for 1998-2001. Approximately 10% of the competitive research grants declined have average award ratings which qualify them for funding. Additional funds to increase size of awards to match NIH would require approximately three times more funding. Additional funds to increase duration of award to match NIH requires approximately 1.5 times more funding.

B. USDA success rate and capacity

Table 2 presents data supplied by the USDA CSREES Competitive Research Grants and Awards Management Office. Based on these estimates, the NRI and IFAFS programs combined could utilize an increase of $674million, a 305% increase from FY'00 funding levels, to support high quality scientific research.

C. Critical Fields of Science to Meet the Challenges

The CRIS categorization of FOS was used by the experiment station directors to estimate the FOSs necessary to address each objective within the seven challenges. These estimates were analyzed by the ESCOP Planning Committee and summary tables including the current SYs, needed SYs, range, and standard deviation for each of the objectives in the seven challenges are available upon request. For subsequent analysis, the focus was on characterizing the additional SYs that are needed to meet the challenges.

Table 3 identifies the five most critical fields of science to meet the need of each challenge area. These are the five FOSs that require the largest addition of SYs to meet that challenge. It is interesting to note that Economics (FOS 3010) is mentioned in 5 of the 7 challenges (Challenge area 1, 3, 4, 5, and 6). Engineering (FOS 2020) was also identified as one of the most lacking in Challenge areas 1, 3, 4, 5, and 7. Molecular biology (FOS 1040) was identified in three challenges. The increase in SYs varied from 45% in Challenge area 1 to 175% in Challenge area 3. Finally, the interdisciplinary nature of the challenges is readily apparent by noting that the top five FOSs only represent approximately 50% of the SYs needed to meet the challenge with the exception of Challenge area 6 (where the top five represent 87% of the needed SYs). Challenge area 6 also requires the greatest concentration of scientists with specialization in the social sciences.

D. Critical Scientist Shortfall

The analysis conducted by the experiment station directors also identified the objective in each challenge area in which there was the largest shortfall of needed scientist years (SYs) (Table 4). The SY needs varied from an 84% increase in SYs for Challenge 1, Objective A, to a 38% increase in Challenge 7, Objective D.

E. Cost per SY in each FOS

Using the CRIS system, the Social Science Research Center at Mississippi State University provided an analysis of the funding supporting the scientists in each Field of Science for both CSREES SYs and ARS SYs. To estimate the required funding for each additional SY, each FOS was placed into one of 6 groups: (1) Group 1 Biological Sciences, (2) Group 2 Nutrition/Epidemiology, (3) Group 3 Ecology/Environmental Sciences, (4) Group 4 Physical Sciences, (5) Group 5 Engineering/Earth Sciences, and (6) Group 6 Social Sciences (Table 5). This methodology was used to smooth out any exceptional outliers in the data. The data on funding for each SY in each FOS was then pooled into the group and the pooled data were used to calculate the investment for a state-funded SY (CSREES data) and an ARS funded SY (ARS data). For the state investment, only the SYs designated as state supported were used since this would largely reflect the investment in faculty.

Table 6A and Table 6B present the results of the investment per SY for a state-supported SY and an ARS supported SY. Interestingly the total investment per SY is similar for both state-supported and ARS supported scientists. This is to be expected based on competition for scientists. More striking is the total dependence on USDA ARS funds for the ARS-funded positions (average 94.7%) contrasted to the state-supported SYs that rely on approximately half the total investment coming from the state. Note that for each state supported SY, nearly $100K (25.3% of $404K) is federal funding much of which is competitively awarded to the scientist. Finally, this analysis demonstrates that ARS scientists are heavily funded internally by direct appropriations to ARS (94.7%).

F. Additional Federal Investment in Current Capacity to Meet the Challenges

Table 7 summarizes the data from Tables 1, 1a and 2 on the additional federal investment in competitive grants programs in NIH and USDA-NRI and IFAFS, respectively, to meet the challenges. For USDA, good science necessary for secure agriculture and food systems into the 21st century requires a tripling of the competitive grants programs ($221M allocated in FY'00 to $674M). NIH, on the other hand, could allocate an additional 69% ($1537M) in the Extramural Research Program for good science.

G. New Investment to Meet the Challenges

Table 8 summarizes the additional investment required to meet the challenges identified in the ESCOP Science Roadmap for Agriculture. The total shortfall in state supported SYs is 5092 (total of column 26), approximately 72% of the current investment in SYs (total of column 24). The total investment for these additional SYs is estimated to be $2.104B (total of column 27) with 43% ($921M) from state investment, 29.7% ($625M) from federal sources, and 26.5% ($558M) coming from non-federal sources. The seven FOSs each requiring an investment in excess of $100M are (1) molecular biology ($202M), (2) nutrition and metabolism ($170M), (3) engineering ($150M), (4) economics ($146M), (5) genetics (including breeding) ($136M), and (7) biochemistry and biophysics ($119M).

III. Summary

During the course of this exercise it became apparent that there were several fields of science that need to be included to adequately address the challenges. These include Bioethics, Biosystems Modeling, Logistics and Transportation, Animal Behavior, Business Management, and Biomedical**.**

This exercise leads to the conclusion that the federal investment in the science of agriculture is woefully lacking if we are to meet the challenges facing agriculture and food systems. Now more than ever is the time for action to ensure a secure, adequate and safe food supply for the American public. This analysis has demonstrated that the federal investment in research programs pertinent to agriculture and its needs must increase by 80 to 100% (ie. a doubling) if the United States is to have a robust agriculture and food supply system.

Table 1. Competitive Research Project Capacity for Research Funding at NIH[a]

		Success Rate (%)[b]			Total $ Awarded (millions)			Unfunded Capacity[c] FY '00 (millions)
NIH Description	**Program Title**	**2000**	**1999**	**1998**	**2000**	**1999**	**1998**	
R01	Research Project	31.4	31.6	30.9	2,100	1,923	1,453	1,400
R03	Small Research Grant	30.3	30.9	30.7	36.8	37.4	39.3	25.5
R15	Academic Research Enhancement Award	7.2	3.6	9.5	2.65	1.11	1.89	16.3
R21	Exploratory/Developmental Grants	24.3	31.7	26.4	91.9	65.4	37.4	91.9
R33	Exploratory/Developmental Grants Phase II	31.3	100	--	4.79	2.08	–	3.19

[a] From NIH homepage for FY '00, '99 and '98.
[b] Based on number of proposals.
[c] Assumes 50% of requested funds is high quality science per discussion with NIH Office of Extramural Grants.

Table 1A. NSF Competitive Research Grant Capacity

Year	Success Rate (%)	Total $ Awarded (millions)	Estimated Unfunded Capacity (millions)[a]
'01	27	2,100	1,300
'00	30	1,800	1,000
'99	30	1,700	1,000
'98	30	1,500	1,000

[a] Approx 10% competitive research grants declined have average award ratings which qualify them for funding.
Additional funds to increase size of awards to match NIH would require approximately three times more funding.
Additional funds to increase duration of award to match NIH requires approximately 1.5 times more funding.

Table 2. Estimate of Underutilized Current Capacity with USDA/CSREES/NRI and IFAFS Programs [a]

			FY '00 Dollars (Millions)			
Program	**Success Rate (%)[b]**	**Fundable (%)[c]**	**Requested**	**Funded**	**Fundable**	**Shortfall**
NRI	16	45	702	110	316	206
IFAFS	8.6	45	1,286	111	579	468

[a] Based on estimates from CSREES Competitive Research Grants and Awards Management Office for FY '00.
[b] Based on dollars awarded and dollars requested.
[c] Based on dollars requested for proposals rated outstanding, high priority and medium priority.

Table 3. Five Most Critical Fields of Science (FOS) to Meet the Challenges

Challenge Area 1 - We can develop new and more competitive crop products and new uses for diverse crops and novel plant species.			
FOS No.	**FOS Title**	**Current SYs**	**Additional SYs**
1040	Molecular Biology	227	161
1080	Genetics (includes breeding)	361	133
3010	Economics	71	126
2020	Engineering	119	121
1130	Entomology and acarology	217	62
Total for top five FOS		995	603
Total for Challenge Area		2,711	1,227
Top 5 as % of total		37%	49%

Challenge Area 2 - We can develop new products and new uses for animals.			
FOS No.	**FOS Title**	**Current SYs**	**Additional SYs**
1040	Molecular biology	156	118
1010	Nutrition and metabolism	224	116
1000	Biochemistry and biophysics	102	83
1080	Genetics (includes breeding)	163	80
1020	Physiology	223	79
Total for top five FOS		868	476
Total for Challenge Area		1,792	1,218
Top 5 as % of total		48%	39%

Challenge Area 3 - We can lessen the risks of local and global climatic change on food, fiber and fuel production.			
FOS No.	**FOS Title**	**Current SYs**	**Additional SYs**
2070	Meteorology/Climatology	32	148
1070	Ecology	110	83
3010	Economics	25	71
2080	Mathematics and computer sciences	3	66
2020	Engineering	38	52
Total for top five FOS		208	420
Total for Challenge Area		494	865
Top 5 as % of total		42%	49%

Challenge Area 4 - .We can provide the information and knowledge needed to further improve environmental stewardship.			
FOS No.	**FOS Title**	**Current SYs**	**Additional SYs**
2020	Engineering	94	83
3010	Economics	90	63
1070	Ecology	43	51
1060	Biology (whole systems)	41	42
2000	Chemistry	80	41
Total for top five FOS		348	280
Total for Challenge Area		759	568
Top 5 as % of total		46%	49%

Challenge Area 5 - We can improve the economic return to agricultural producers.			
FOS No.	**FOS Title**	**Current SYs**	**Additional SYs**
3010	Economics	280	49
3080	Sociology	23	34
2090	Statistics, econometrics and biometrics	1.5	33
2020	Engineering	43	24
2080	Mathematics and computer sciences	0.4	19
Total for top five FOS		348	159
Total for Challenge Area		388	307
Top 5 as % of total		90%	52%

Challenge Area 6 - We can strengthen our communities and families.			
FOS No.	**FOS Title**	**Current SYs**	**Additional SYs**
3010	Economics	49	54
3080	Sociology	82	48
3030	Information/Communication	7	20
3020	Education	8	17
3100	Management	5	8
2090	Statistics, econometrics and biometrics	0.4	8
Total for top five FOS		151	155
Total for Challenge Area		235	179
Top 5 as % of total		64%	87%

Challenge Area 7 - We can insure improved food safety and health through agricultural and food systems.			
FOS No.	**FOS Title**	**Current SYs**	**Additional SYs**
1010	Nutrition/Metabolism	150	137
1040	Molecular Biology	32	90
1000	Biochemistry/Biophysics	83	72
1100	Bacteriology	51	51
2020	Engineering	61	47
Total for top five FOS		377	397
Total for Challenge Area		683	764
Top 5 as % of total		55%	52%

Table 4. Objective in Each Challenge Area Requiring Largest Percentage Increase in SYs

Challenge	Objective	% Increase in SYs
1 - We can develop new and more competitive crop products and new uses for diverse crops and novel plant species.	**A** - Improving crop biomass quantities, qualities and agricultural production efficiencies.	84
2 - We can develop new products and new uses for animals.	**A** - Improving conventional technologies as well as developing new technologies to improve the efficiency of animal production.	66
3 - We can lessen the risks of local and global climatic change on food, fiber and fuel production.	**A** - Diminishing the rate of long-term global climatic change by increasing the storage of carbon and nitrogen in soil, plants and plant products.	47
4 - We can provide the information and knowledge needed to further improve environmental stewardship.	**B** - Decreasing our dependence on chemicals with harmful effects to people and the environment by optimizing their use in effective crop, weed, pest and pathogen management strategies.	57
5 - We can improve the economic return to agricultural producers.	**B** - Developing sustainable production systems that are profitable and protective of the environment, including ways to optimize the integration of crop and livestock production systems.	36
6 - We can strengthen our communities and families.	**D** - Determining strategies to enhance the well-being of families and individuals.	43
7 - We can insure improved food safety and health through agricultural and food systems.	**D** - Eliminating food borne illnesses.	38

Table 5. Discipline Groups by FOS Category

Biological Sciences - Group 1	
1000	Biochemistry and biophysics
1020	Nutrition and metabolism
1030	Cellular biology
1040	Molecular biology
1050	Developmental biology
1060	Biology (whole systems)
1080	Genetics (includes breeding)
1090	Immunology
1100	Bacteriology
1101	Virology
1102	Mycology
1103	Other microbiology (includes protozoology, phycology)
1150	Toxicology
1160	Pathology
1180	Pharmacology
Nutrition/Epidemiology - Group 2	
1010	Nutrition and metabolism
1170	Epidemiology
Ecology/Environmental Sciences - Group 3	
1070	Ecology
1110	Parasitology
1120	Nematology
1130	Entomology and acarology
1140	Weed science
1190	Limnology
Physical Sciences - Group 4	

2000	Chemistry
2010	Physics
2080	Mathematics and computer sciences
Engineering/Earth Sciences - Group 5	
2020	Engineering
2030	Geology
2040	Mineralogy
2050	Hydrology
2060	Geography
2061	Pedology
2070	Meteorology and climatology
3111	Landscape architecture
Social Sciences - Group 6	
2090	Statistics, econometrics, and biometrics
3000	Anthropology
3010	Economics
3020	Education
3030	Information and communication
3040	History
3050	Law
3060	Political science
3070	Psychology
3080	Sociology
3090	Sensory science (human senses)
3100	Management
3110	Art and architecture

Table 6A. Cost of SYs (CSREES Data from CRIS)

Group	Total ($000/SY)	State (%)	Federal (%)	Other (%)
Biological Sciences	469	35.4	38.1	26.5
Nutrition/Epidemiology	507	41.9	32.8	25.3
Ecology/Environmental Sciences	333	51.7	16.9	31.4
Physical Sciences	386	51.1	23.4	25.5
Engineering/Earth Sciences	394	55.0	17.0	28.0
Social Sciences	337	51.5	23.7	24.8
Average	404	47.8	25.3	26.9

Table 6B. Cost of SYs (ARS Data from CRIS)

Group	Total ($000/SY)	ARS (%)	Federal (%)	Other (%)
Biological Sciences	353	98.7	0.81	0.50
Nutrition/Epidemiology	425	97.3	1.95	0.74
Ecology/Environmental Sciences	336	97.3	2.28	0.46
Physical Sciences	353	97.6	2.10	0.34
Engineering/Earth Sciences	325	88.6	6.74	4.66
Social Sciences	385	88.8	11.2	0
Average	363	94.7	4.18	1.12

Table 7. Additional Federal Investment in Current Capacity to Meet the Challenges

Program	Current Investment ($ Millions)	Additional Investment ($ Millions)
USDA-NRI	110	206
USDA-IFAFS	111	468
NIH (Extramural only)	2,236	1,537

Table 8. Analysis of Current Scientific Capacity and Estimates of Future Needs

(See Excel file at http://www.escop.msstate.edu/archive/roadmap-table8.xls **.)**