AGRICULTURAL SAFETY AND HEALTH PROGRAM

DEPARTMENT OF AGRICULTURAL AND BIOLOGICAL ENGINEERING
PURDUE UNIVERSITY
WEST LAFAYETTE, INDIANA

Program Mission Statement

The fundamental mission of Purdue's Agricultural Safety and Health Program (PUASHP) is to enhance the quality of life for rural residents of the state, especially farm families, through assisting them with making their homes, work places, and communities the safest and healthiest possible places to live and work. It is further believed that this program has the capacity to impact rural safety and health on a national and international basis through preparation of future rural safety and health professionals and agricultural leaders and educators; development, demonstration, and evaluation of injury and disease prevention strategies; development of new knowledge; increased public awareness; dissemination of educational resources; and influence of public policy.

A meeting was held at Purdue University in 1942 to address the high frequency of farm-related injuries and fatalities, and their impact on the wartime food production efforts. This led to the formation of a Farm Safety Committee, with support from the National Safety Council, which eventually became the Indiana Rural Safety and Health Council.

Primary Program Areas

Activities associated with the PUASHP have historically been categorized into three areas:

1. Prevention of rural and agricultural-related injuries and occupational illnesses
2. Rural emergency preparedness, including agrosecurity
3. Rehabilitation assistance for farmers, farm family members, and agricultural workers impacted by disability

The primary emphasis of the program since its establishment in 1945 has been the prevention of rural and agricultural-related injuries. Efforts have also been made to address the more common types of occupational illnesses associated with agricultural production. Reducing the incidence of injury and disease among the target population has the greatest potential for long term benefits and reduces the need for investments into the remaining two program areas.

F.R. Willsey, a navy veteran, was hired in 1945 to become the state's first Farm Safety Leader. He was located in the Agricultural Engineering Department, and held the position for over 30 years, retiring in 1976.

Important contributions to improve farm safety have been made through efforts to enhance the guarding of PTO-operated equipment; promoting

safe grain storage and handling practices; delivery of farm safety education into the Amish/Old Order communities; reducing the frequency and severity of farm-related injuries involving children and young workers; and developing evidence based instructional material for secondary agricultural education programs.

The outcomes from program activities in the rural emergency preparedness area have included: greater public awareness of the severity and personal and economic impact of rural injuries and agricultural-related disasters; reduced mortality rate for injuries that frequently become life threatening due to the length of response time, inappropriate response techniques and lack of agricultural-related first response training; increased emergency medical and rescue capability in rural communities; and enhanced personal and community preparedness for natural and human caused disasters. The program has contributed to the establishment of early emergency medical services, conduct of Civil Defense efforts during the "Cold War", and support of Homeland Security programs following the attacks of 9-11.

Early in his career, Professor Willsey worked with local undertakers and funeral directors to enhance their capacity to respond more effectively to farm-related injuries. Hearses got double duty as ambulances.

When Professor Willsey began as a Farm Safety Specialist, the big issues he dealt with were livestock-related injuries, including horses and bulls, and falls. There was still a lot of "horse power" in use on Indiana farms in the 1940s and early 1950s.

Since 1979, the PUASHP Breaking New Ground Resource Center and Outreach Program (AgrAbility Program since 1992) has offered a variety of rehabilitation services to farmers, ranchers and agricultural workers who have desired to remain productive in agriculture despite severe physical and behavioral disabilities. This area of activity has brought considerable attention to the program and has resulted in significant services that have not been readily available through traditional Extension channels. Activities have included: design and development of appropriate assistive technology for agricultural workplaces, prevention of secondary injuries due to limitations caused by disability, on-site technical consultation, referrals to appropriate agencies, dissemination of information and relevant resources, peer support networking, and public awareness activities. The Breaking New Ground Resource Center was a catalyst for the establishment of the AgrAbility Program in the 1990 USDA Farm Bill that now serves farmers, ranchers, and agricultural workers throughout the U.S. From 1991-2000 and from 2008 to the present, the program has provided leadership for the National AgrAbility Project with an emphasis on supporting AgrAbility-funded state projects and serving states without AgrAbility Projects. Between 1993 and 2002, the program provided a home for Purdue's THE CHAPS Program (Therapy, Health, and

Professor Willsey earned his Ed.D. from Indiana University while on-the-job at Purdue. He was known locally as an apple grower and producer of Christmas trees.

In 1954, Professor Willsey was using custom modified toy tractors that had been motorized to demonstrate tractor stability and the high risk of overturn when going uphill or making sharp turns.

Education through Children and Horses As PartnerS). This nationally accredited program provided therapeutic horse-related activities for children with disabilities and served as a training center for instructors.

Early Agricultural Health and Safety Efforts – 1945-1976

For the first three decades, the PUASHP thrived under the leadership of Professor F.R. (Dick) Willsey who was recognized as a premier example of the traditional Extension education specialist. He traveled extensively, including by train, promoting farm safety wherever he could gain an audience. He was innovative in the use of safety plays and skits, audiovisual materials, demonstrations, and dynamic exhibits. Long before tractor rollovers became a national concern, he was conducting actual tractor overturn demonstrations using a remote controlled tractor to illustrate the high potential for death from this type of incident. When modern grain bins were first employed, he developed graphic displays demonstrating the hazards of flowing grain and the potential for entrapment. In response to a lack of rural emergency medical services, he was active in promoting first aid training for farm families and later the organization of volunteer rural emergency medical units. His belief in the need for grassroots involvement led to a thirty-year involvement with the Indiana Farm Safety Council (Indiana Rural Safety and Health Council), where he acted as a catalyst for a wide range of statewide rural safety and health efforts. Throughout his 30 plus year tenure as Extension Safety Specialist, he maintained a strong commitment to working with children and youth. He recognized early on that if attitudes and behavior were to change, they had to start with children. As a result, Purdue's Agricultural Safety and Health Program has always been heavily involved in promoting child safety and working with rural youth groups such as 4-H and FFA.

Between 1967 and 1969, Professor Willsey and J.B. Liljedahl interviewed 145 victims of non-fatal tractor overturns and found that 83% occurred to the side and 25.5% were equipped with front-end loaders. None of the tractors involved were equipped with any form of rollover protection.

The use of community-based theater was developed in the 1950s to promote farm safety and emergency preparedness through plays written by Professor Willsey.

During the early 1950s, F.R. Willsey began organizing support groups for farmers who had lost limbs after becoming entangled in corn pickers. These groups became known as "one-arm-cornpicker clubs".

During the 1960s the Agricultural Engineering Building became a repository of educational resources related to the risks to agriculture from nuclear/radioactive fallout. The stockpile included a large number of Geiger Counters and plans for building fall-out shelters.

One noteworthy initiative was the design of a statewide fire prevention initiative involving 4-H and FFA members This involved youth in conducting farm and home fire safety inspections

and implementing corrective measures. Tens of thousands of youth were involved, with outstanding contributors being awarded gold watches.

Throughout the 1960s, Professor Willsey conducted hearing tests of farmers attending various farm shows. He utilized a homemade hearing booth that looked like an old phone booth.

Professor Willsey and other members of the Purdue staff were also involved with attempting to better understand the nature of agricultural injuries through ongoing applied research. The results of this research were used primarily for designing injury prevention programs and public awareness efforts. Early studies involved investigations of injuries associated with tractors, corn pickers, and other agricultural equipment and rural home-related injuries. The following is a partial listing of several of the early externally sponsored research projects conducted at Purdue.

1. Purdue Farm Cardiac Project - 1964-1967.
   Study of risks associated with returning to farm work following a heart attack.
   Cooperators: Purdue University, Indiana Heart Association
2. Accident Prevention by Control of Tractor Tipping - 1970-1972.
   Study of tractor stability to reduce the frequency of overturns.
   Cooperators: Purdue University, U.S. Department of Health, Education, and Welfare.
3. Investigation of Anhydrous Ammonia Accidents on Indiana Farms - 1972-1974.
   Study of injuries resulting from exposure to agricultural anhydrous ammonia.
   Cooperators: Purdue University, State Chemist Office, National Safety Council
4. Develop and Field Testing of Agricultural Safety Education Materials - 1974-1977.
   Preparation and field testing of safety materials to be used by agricultural workers, including migrant and seasonal workers.
   Cooperators: Purdue University, U.S. Department of Labor.
5. Survey of Indiana Farm Accidents - 1965-1966 and 1976-1977.
   Surveys of statewide farm accidents to determine the nature and magnitude of serious farm-related injuries.
   Cooperators: Purdue University, National Safety Council, Indiana Extension Homemakers, Indiana Farm Safety Council, NIOSH

Professor Willsey was deeply involved with enhancing the capacity of the Cooperative Extension Service to prepare for and respond to both human caused and natural disasters. Purdue's Agricultural Engineering Building's attic became a repository for literally tons of resources related to responding to the potential for nuclear attack during the 1960s. This included a stockpile of radiation detection equipment, training materials related to nuclear fallout protection, and educational displays on family preparedness. The last version of the Rural Civil Defense Handbook for Extension Agents was printed at Purdue and copies distributed to every county Extension office in the U.S. (1978). The position of Extension Safety Leader was a permanent position on the Indiana/USDA Statewide

A source of income for the original ASM Club was the sale of hearing protection to farmers at various public events. This was done to compliment Professor Willsey's hearing conservation program.

Emergency Preparedness Taskforce that managed the state's disaster management plan.

From 1974-1977 PUASHP led an effort supported by the U.S. Department of Labor to help equip farmers to meet the workplace safety and health requirements of the Occupational Safety and Health Act passed by Congress in 1970. This led to a wide range of farm safety materials published in low and high literacy levels of English and low and high literacy levels of Spanish. This effort, not understood by several of the national farm organizations, led to the materials receiving the infamous Senator Proxmire Gold Fleese Award as an example of a waste of tax payers' money. Not withstanding the bad press, hundreds of thousands of the publications were printed and distributed nationally. The Agricultural Tractor Safety film, produced as part of the project, became one of the most widely distributed farm safety films ever produced. It was distributed in both English and Spanish.

A series of publications developed in 1974-1977 to promote farm safety was awarded the infamous "Golden Fleece Award" by Senator Proximire of Wisconsin. The work was supported by the U.S. Department of Labor and was an attempt to provide resources at a reading level compatible with farm workers at the time.

During the 1960s, Professor Willsey used a John Deere, Model B tractor operated remotely with an umbilical cord to demonstrate tractor roll over hazards. The tractor was "driven" by a dummy with a glass jug for a head, nicknamed "jughead".

Other activities carried out by Professor Willsey included work with rural funeral directors and undertakers to utilize hearses to provide emergency transport during medical emergencies. First aid training was provided to drivers. Another unique service provided was the hosting of peer support groups for farmers who lost limbs due to entanglements in corn pickers. During the late 1940s through the early 1960s, over 100 Indiana farmers a year were losing a hand or arm in corn pickers before self-propelled combines were introduced. These groups became known as "One Arm Corn Picker Clubs."

One of Professor Willsey's better known graduate students was Dr. A.H. Ismail who became a nationally recognized health and wellness specialist after whom the Purdue Ismail Center was named.

Agricultural Safety and Health Efforts 1977-Present

In 1977, William E. (Bill) Field replaced Professor Willsey who had retired the previous year. Building on the work started by Professor Willsey, with his continued support, Professor Field became heavily involved in coordinating and promoting local agricultural safety activities throughout the state. He

In 1978, Professor Field made his first international trip as a Purdue faculty member to St. Lust, Guyana, where he learned about the hazards of rain forest farming practices that included large spiders and venomous reptiles.

Professor Field has conducted agricultural safety and health activities in over 37 states, 5 Canadian provinces, and 13 foreign countries.

sought to involve as many groups as possible in program efforts including Farm Bureau, 4-H, FFA, Extension Homemakers, insurance companies, implement dealers, and community organizations.

The first Ph.D. graduate of Purdue's Agricultural Safety and Health Program, under Professor Field was Roger Tormoehlen, who went on to serve as a Department Head at Purdue for 11 years.

During the past four decades, under the leadership of Professor Field, PUASHP has gained additional national and international recognition. Professor Field developed both undergraduate classes (ASM 350 and ASM 510) and graduate programs that have exposed thousands of students to the field of agricultural safety and health. His coordination of graduate level research has resulted in the awarding of nearly 45 graduate degrees in the field and dozens of research reports and published works that have contributed substantially to the current body of knowledge.

Professor Field spent two summers (1982 and 1984) in Luoyang, China working at the Chinese Tractor Research Center teaching English to engineers and contributing to making Chinese farm equipment safer. The use of machine guarding was almost non-existent at the time.

The PUASHP and other program staff have been consulted for their expertise in development of injury prevention and rural rehabilitation programs by numerous organizations and companies throughout the U.S., Canada and several other countries. Staff has provided technical and educational services for major farm organizations, 4-H, FFA, many of the major agricultural equipment manufacturers, state and federal agencies, insurance companies, rural hospitals, and numerous agricultural businesses. Over the past four decades, Professor Field has been called upon to provide expert testimony in over 130 civil cases involving agricultural-related deaths and injuries.

Some of the recent accomplishments are summarized as follows:

1. Dissemination of agricultural safety and health information.

In 1977, Professor Field submitted a resolution to the National Institute for Farm Safety to ban smoking at their professional meetings. The overwhelming majority voted the resolution down when the southern delegates threatened to terminate their membership. Ten years later, Professor Field worked with Professor Sam Parsons to develop a smoking policy for ABE, that restricted smoking to private offices. Efforts were also made to designate university owned vehicles as "smoking" versus "non-smoking".

Extensive use has been made of the farm and rural media networks to promote safer and healthier work practices. Since 1977, over 970 news releases, stories, and articles related to farm safety have been published based on work done at Purdue. In addition, over 450 radio and TV interviews have been conducted. This has included special reports by NPR, CNN, ABC, *Market-to-Market*, *Ag Day*, NBC, 60-Minutes and other nationally syndicated media organizations and programs.

Professor Field's 10-year-old son Evan played an important role in having the "AgrAbility" program added to the 1990 Farm Bill by visiting with Congressman Jamie Whitten during an Appropriations Committee meeting.

Several of Purdue's agricultural injury prevention materials have found wide acceptance and use with farmers and agricultural safety professionals throughout the United States. Over 1,250 copies of Purdue's 22 minute *Agricultural Tractor Safety* film have been sold across North America, making it one of the most popular agricultural safety films ever produced. The film was modified with a Spanish sound track for use in Texas and California, where there are large numbers of Spanish speaking farm workers. *Suffocation Hazards in Flowing Grain*, produced at Purdue, was the standard audio-visual presentation on flowing grain hazards for over 20 years, being used widely with farmers and grain handlers. Several of Purdue's safety publications, developed under a contract with OSHA, were designed specifically for use with agricultural workers with Spanish or limited reading skills, and have been reproduced in other states in large quantities.

Over 250,000 copies of Careful Country, a family oriented coloring and activity book promoting farm safety were distributed from the back of the original ABE Building.

One of the program's most successful agricultural injury prevention strategies has been the use of family oriented coloring and activity books. This has included *Safety on the Farm*, a farm safety coloring book designed for use with children and their parents. Over 95,000 copies were produced and distributed throughout the United States. The second edition of the coloring book, *Careful Country Farm Safety and Activity Book*, became available in 1994. Over 250,000 copies were printed and distributed. In addition to the coloring book, an accompanying *Careful Country Teacher's Kit* was produced to aid parents and educators in teaching farm safety to children. Nearly 900 kits were purchased by safety leaders and school teachers across the country.

Professor Field initiated the first aluminum can recycling program in ABE using the funds to support the Breaking New Ground Resource Center. A small building was built to store the cans between trips to the recycling center. It was so successful that the University took it over.

In 1996, in response to the growing number of farm-related fatalities and injuries in Amish and Old Order communities, Purdue worked in conjunction with the Indiana Rural Safety and Health Council and The Northern Indiana Family Safety Committee to produce *Weeds in Our Garden*. This child oriented coloring and activity book was designed specifically for use by Amish children. Over 35,000 copies have been distributed nationally. A second publication on Amish buggy safety, *Sharing the Road*, was developed with support from the Governor's Task Force on Impaired and Dangerous Driving. Over 70,000

To promote the passage of the ADA in 1990, Professor Field helped organize an "unofficial" Visit the State Fair Day for Persons with Disabilities. This helped bring attention to the lack of accessible parking, restroom facilities, and exhibit areas, which led to major renovations to enhance the accessibility of the fairgrounds.

copies were circulated to Amish communities nationwide, for distribution to non-Amish motor vehicle operators.

One of the first websites on farm safety resources for children (*farmsafety.org*) was established in 1995 by Purdue in cooperation with the Indiana Rural Safety and Health Council. This has been expanded regularly to include new resources and links with other programs. In 2001, the site received a national educational award from ASABE. Additional websites developed to disseminate safety information include: (www.ruralcare.org), (www.agsafety4youth.org), (www.grainsafety.us), and (www.agconfinedspaces.org).

The PUASHP was funded by NIOSH to conduct some of the first research on the effectiveness of computer-based learning of students participating in required training under the Hazardous Agricultural Occupations Order.

With support from NIOSH/CDC and USDA-CSREES, and in collaboration with Professor Roger Tormoehlen of Purdue's Department of 4-H and Youth, the program has been involved since 1995 in developing and testing comprehensive, research based, agricultural safety curricula for youth employed in agricultural production. The Gearing up for Safety – Agricultural Production Safety for Youth curriculum was designed to meet the federal training requirements and address the most significant causes of farm-related injuries. The curriculum is currently available on the web at www.agsafety4youth.org. Over 1,000 copies of the student interactive CD and 17,000 copies of the instructor CD have been distributed nationally. The program is currently under revision with support from USDA/NIFA.

Professor Field was cited by the Indiana Department of Environmental Management for the intentional release of liquid anhydrous ammonia as part of a "live" training session for emergency first responders. The claim was that the ammonia was not being used for agricultural purposes.

With support from a U.S. Department of Labor, Susan Harwood grant, the program developed two evidence-based curricula that addressed grain handling and storage safety. One of the curricula was designed for emergency personnel responding to grain-related entrapments. The second targeted young and beginning workers in the grain industry. The project included training for local instructors and development of new web-based resources. Over 26,000 copies of the project's grain safety publication have been distributed at public awareness events. In 2016 the PUASHP worked with the Posey County, Indiana Farm Bureau to produce "Stop, Think, Live", a video of a reenactment of an actual grain bin entrapment. Over 700 copies have been distributed to Indiana Extension educators, agricultural teachers, and farm organizations.

For more than 50 years, PUASHP and the Indiana Rural Safety and Health Council has coordinated exhibits and conducted safety demonstrations at the Indiana State Fair reaching hundreds of thousands of people with the farm safety message.

The PUASHP has worked to endow two university scholarships – one for students who have lost a parent due to a farm-related fatality and a second for students with a disability pursuing a degree in agriculture.

2. Improve the quality of agricultural injury data.

It is widely accepted that the present system of collecting agricultural injury data has many weaknesses. Presently there are fewer than 10 states that maintain and make available farm fatality data for analysis. The use of encoded data from death certificates used at the national level has major shortfalls, with nearly one-third of the cases not clearly indicating the agent involved or cause of death.

For a period of more than 25 years, the Indiana Department of Health and Purdue cooperatively worked together to identify reports of farm-related deaths and suicides involving Indiana "farm residents." These data have been analyzed and reported in several fashions including on the website, www.farmsafety.org. Two past studies looked at farm-related deaths involving those under 15 and those over 60. In addition, a statewide clipping service has been utilized in identifying fatal and non-fatal farm injuries reported through the press. In 1985, M.A. Purschwitz, recently retired from the University of Kentucky, undertook a graduate study to evaluate various methods of collecting and handling agricultural fatality and injury data. This work contributed to the development of the ASABE Farm and Agricultural Injury Classification (FAIC) Code. Over 15,000 farm-related fatality and severe injury cases were assembled and catalogued from all 50 states. These data have been used to conduct a comparative study of farm-related fatalities involving children in Indiana and Wisconsin, a study of children suffocated in grain transport vehicles, an investigation of on-farm grain storage entrapments, studies of PTO-related injuries and manure pit entrapments, and a summary of injuries to Amish farmers.

The National AgrAbility Project was awarded to PUASHP in 1991 and has been housed there for 20 of its 28 years in existence.

The PUASHP established one of the first agricultural safety and health websites in the U.S. (www.farmsafety.org).

National databases are currently maintained and being expanded on incidents involving agricultural grain storage entrapments, manure storage and handling facilities, and bull attacks.

3. Train rural leaders to increase their effectiveness in promoting agricultural safety and health issues.

Since 1977, over 1,900 students preparing to become farmers, agricultural education teachers, county Extension educators and agribusiness managers, have enrolled in Professor Field's agricultural safety and health class (ASM 350) offered in Purdue's Agricultural and Biological Engineering Department. This class provides a basic overview of agricultural safety and health issues, equips each student with a set of prepared lesson plans to assist them in presenting safety and health topics on their

The PUASHP and AgrAbility teams shipped out over 1.75 million printed and audio visual resources from the "corner office" in the old ABE shop that was demolished to make room for the new building. The women from the Sigma Alpha Sorority volunteered thousands of hours to prepare many of these mailings.

own, and requires completion of an on-farm safety inspection. Over 1,500 different farms in the state have been involved in these safety audits.

In addition, numerous workshops and presentations have been made to rural leaders and educators throughout the state and nation. A wide variety of training materials have been prepared to provide rural educators the essential tools to disseminate agricultural safety and health information. Examples of these include:

3.1 *Eye Hazards on the Farm* - Slide and video tape program with accompanying teacher's kit

3.2 *Don't Gamble With Your Eyes* - Educator's resource kit

Since 1977, PUASHP educational programs and resources have been awarded over 30 Blue Ribbon Awards from the American Society of Agricultural and Biological Engineering.

3.3 *Farm Women Safety Workshop Kit* - Educator's resource kit with visuals

3.4 *Using Grain Harvesting Equipment Safely* - Educator's resource kit with visuals

3.5 *Using Anhydrous Ammonia Safely* - Educator's resource kit with visuals

3.6 *Flowing Grain Hazard Alert Program* - Educator's resource kit

3.7 *Farming with Arthritis* - Slide and video tape program

3.8 *Farm Family Safety and Health Workshop* - Leader's guide

3.9 *Farm and Ranch Safety Management* - Student guide and instructor's guide

3.10 *Careful Country Teacher's Kit* - Educator's resource kit with visuals

3.11 *Don't Go With the Flow* - Educator's kit/video on commercial grain storage rescue

As part of an exhibit at the Indiana State Fair to demonstrate the potential severity of tractor rollovers, Professor Field used a volunteer made up to look severely injured and placed him under an overturned tractor. Not realizing that the incident was a re-enactment, the State Police stepped in and took over the scene calling in emergency medical services. The demonstration was memorable for everyone.

3.12 *We all Share the Road* - Rural traffic safety DVD

3.13 *Gaining Ground on Arthritis* - Managing arthritis in the work place DVD

3.14 *Gearing up for Safety* – Agricultural safety training for youth

3.15 *Against the Grain* – Grain safety curriculum for young and beginning workers

3.16 *Basic Awareness Training for Emergency Personnel Responding to Grain Entrapment*

From 1990-1998, the program coordinated the Rural Indiana Safer Kids Project (RISK), with support from the Indiana Department of Health that was designed to train rural leaders to become more effective at promoting rural childhood injury prevention. This project resulted in hundreds of child safety events and presentations to tens of thousands of children at farm safety camps and at school-based programs.

The PUASHP developed and offered one of the first courses in the country on the topic of Agrosecurity. This effort led to the development of two additional courses on the foundations and applications of homeland security.

Since 1977, the educational programming efforts of the PUASHP have received over 30 ASABE Blue Ribbons for outstanding contributions to the field of engineering and Extension education.

In 2002, a new series of presentations on emergency preparedness for agricultural production sites were developed and field tested with farm operators. In 2003 the material was offered as a pilot three credit graduate level course in Agricultural and Biological Engineering (ASM 510 Agrosecurity). This class is designed to assist future agricultural managers in preventing, preparing for, responding to, and recovering from both natural and man-made disasters. The class involves a service learning project that requires students to develop an emergency response plan for an agricultural production site.

In 2006 with support from the Indiana Department of Homeland Security, PUASHP staff participated in the development of two graduate level classes dealing with the foundations and applications of homeland security. These two courses have been team taught each year since 2007 with faculty from several departments exposing hundreds of Purdue students to career opportunities in the field of emergency preparedness and response.

Denise Heath has served faithfully as an assistant and secretary for the PUASHP for the past 42 years.

4. Conduct in-depth investigations into specific high risk areas of agricultural production.

Much of the earlier work done on the broad problem of "farm accidents" involved little in-depth investigation based on epidemiological approaches. After completion of the first three statewide farm injury surveys in Indiana in the 1970s and 1980s, the conclusion was drawn that not much had changed in the big picture and that little was still known about the nature of specific types of workplace injuries. Because of the evident lack of prior research, recent Purdue efforts use on-going data collection to focus on specific high risk areas. For example, as a result of the concentrated research efforts on confined space and flowing grain entrapments, more effective educational materials were developed and more meaningful design recommendations were made to the manufacturers of grain storage facilities and grain transport vehicles to reduce the risk of flowing grain entrapment. This led to the PUASHP submitting the first proposal for an ASABE grain bin standard in 1990 to enhance the safety of corrugated steel grain structures. Another good example of the impact of this type of research was the increased use by leading tractor manufacturers of the moveable power-take-off master shield which was shown superior by a Purdue study. See the section on graduate-level research for examples of other recent research efforts.

A commitment to in-depth research and graduate education has also resulted in over 90 peer-reviewed journal articles on various areas related to agricultural safety and health. This includes the following:

4.1 Field, W.E. "Stresses on Minnesota's Rural and Farm Families," ***The Visitor***, Division of Agricultural Education, University of Minnesota, Vol. LXV, No. 3, July 1978.

4.2 Field, W.E. and M.A. Purschwitz. Cost of Farm and Rural Injuries. ***Public Health Reports,*** 102(6):642-644, November-December 1987.

4.3 Wilkinson, T.L. and W.E. Field. Safety Issues Relating to Agricultural Machines Modified for Disabled Operators. ***Trends in Ergonomics/Human Factors.*** Elsevier Science Publishers B.V. (North-Holland), pp. 675-682, 1988.

4.4 Wilkinson, T.L. and W.E. Field. Documentation of Agricultural Tractor and Combine Modifications for Physically Disabled Operators. ***Assistive Technology,*** Volume 1, No. 2, 1989.

4.5 Barrett, J.R., R.S. Williams, and W.E. Field. Impact of Corn Cob Fueled Biomass Furnace Exhaust on Air Quality. ***Transactions of the ASAE,*** 32(3):963-967, 1989.

4.6 Purschwitz, M.A. and W.E. Field. Scope and Magnitude of Injuries in the Agricultural Workplace. ***American Journal of Industrial Medicine,*** 18:179-192, 1990.

4.7 Purschwitz, M.A. and W.E. Field. Fatal Farm Injuries to Older Workers. ***Work: A Journal of Prevention, Assessment, and Rehabilitation,*** 2(1):47-53, 1991.

4.8 Shutske, J.M., W.E. Field, L.D. Gaultney, and S.D. Parsons. Agricultural Machinery Fire Losses: A Preventative Approach. ***Applied Engineering in Agriculture,*** Vol. 6, No. 5, pp. 575-581, 1991.

4.9 Freeman, S.A., D.A. Brusnighan, and W.E. Field. Selecting Mobility Aids for Farmers and Ranchers with Physical Disabilities. ***Technology and Disability,*** 1(4):63-76, 1992.

4.10 Freeman, S.A., D.D. Jones, and W.E. Field. Rural Assistive Technology Hypermedia Decision Support System. ***Applied Engineering in Agriculture.*** 10(6):823-830, 1994. (1995 ASAE Paper Award).

4.11 Tormoehlen, R.L. and W.E. Field. A Perfect Fit — Involving Youth with Disabilities in 4-H. ***Journal of Extension,*** 32(1), pp. 5, 1994.

4.12 Shutske, J.M., W.E. Field, and J. Chaplin. Grain Combine Fires: A Loss Reduction Approach. ***Applied Engineering in Agriculture,*** 10(2):175-182, 1994.

4.13 Freeman, S.A. and W.E. Field. Selection of Rural Assistive Technology Using a HyperCard Based Knowledge System. ***Assistive Technology,*** 6(2):126-133, 1994.

4.14 Tormoehlen, R.L. and W.E. Field. Projecting Economic Losses Associated with Farm-related Permanent Disabilities. ***Journal of Agricultural Safety and Health,*** 1(1):27-36, 1995.

4.15 Allen, P.B., W.E. Field, and M.J. Frick. Assessment of Work-related Injury Risk for Farmers and Ranchers with Physical Disabilities. ***Journal of Agricultural Safety and Health,*** 1(2):71-81, 1995.

4.16 Whitman, S.D. and W.E. Field. Assessing Senior Farmers' Perceptions of Tractor and Machinery-related Hazards. ***Journal of Agricultural Safety and Health,*** 1(3), 1995.

4.17 Sheldon, E.J., W.E. Field, and R.L. Tormoehlen. Fatal Farm Work-related Injuries Involving Children. ***Issues in Agricultural Health and Safety,*** CRC Press, pp. 355-362, 1995.

4.18 Allen, P.B., M.J. Frick, and W.E. Field. The Safety Education Training Needs of Farmers and Ranchers with Physical Disabilities. ***Journal of Agricultural Education,*** 36(3), 1995.

4.19 Tormoehlen, R.L. and E.J. Sheldon. ATV Use, Safety Practices, and Injuries Among Indiana's Youth. ***Journal of Safety Research,*** 27(3):147-155, 1996.

4.20 Kelley, K.W. and W.E. Field. Characteristics of Flowing Grain-related Entrapments and Suffocations with Emphasis on Grain Transport Vehicles. ***Journal of Agricultural Safety and Health,*** 2(3):143-145, 1996.

4.21 Freeman, S.A., K.W. Kelley, D.E. Maier, and W.E. Field. Review of Entrapments in Bulk Agricultural Materials at Commercial Grain Facilities. ***Journal of Safety Research,*** 1996.

4.22 Freeman, S.A., K.W. Kelley, D.E. Maier, and W.E. Field. Entrapments in Bulk Agricultural Materials at North America Commercial Grain Facilities. ***Bulk Solids Handling,*** 17(3):405-406, 1997.

4.23 Freeman, S.A., S.D. Whitman, R.L. Tormoehlen, and K.M. Embleton. Internet Childhood Safety and Health Resource Guide. ***Journal of Extension,*** 35(2), www.joe.org, 1997.

4.24 Freeman, S.A., S.D. Whitman, and R.L. Tormoehlen. Baseline Childhood Farm Safety Data for Indiana. ***Journal of Agricultural Safety and Health,*** 4(2):119-130, 1998.

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5. Provide graduate level opportunities for individuals in the field of agricultural safety and health.

Purdue's Agricultural Safety and Health Program has set a goal to prepare the very best agricultural safety and health researchers and educators possible. It is anticipated that the demand for these individuals, both in the United States and abroad, will increase as the sensitivity to agricultural safety and health issues increases. Presently, few other graduate programs in the United States offer this type of formal preparation. During the past 40 years, nearly 45 graduate-level degrees in Agricultural Systems Management with a specialization in agricultural safety and health have been completed. Over 20 of these graduates are presently in leadership roles in the agricultural safety and health profession, Extension education, or teaching at the university or college levels.

The graduate program in agricultural safety and health within the Department of Agricultural and Biological Engineering utilizes an interdisciplinary approach involving areas of course work outside the field of agricultural engineering to prepare strong plans of study. These areas include educational psychology, industrial safety, industrial engineering, agricultural education, human factors, health education, and industrial hygiene.

More than 15 graduates from the PUASHP have ended up in university academic positions including at Purdue, Iowa State, University of Nebraska, Texas A&M, University of Kentucky, University of Illinois, Murray State, Indiana State University, Ohio State University, and University of Wisconsin.

The following is a summary of graduate degrees that have been awarded to date:

5.1 J.F. Durkes, M.S. *Assessing Needs of Vocational Agriculture Teachers with Respect to farm Safety.* May 1982.

5.2 R.L. Tormoehlen, M.S. *Determining the Proportion and Nature of Physical Handicaps Affecting Active Farm Operators in Indiana.* May 1982.

5.3 W.E. Sell, M.S. *Analysis of Power-Take-Off Related Accidents.* December 1984.

5.4 R.L. Tormoehlen, Ph.D. *Economical Modeling of the Losses Associated with Farm-Related Permanent Disabilities.* May 1985.

5.5 R.S. Williams, M.S. *Biomass and the Environment.* May 1985.

5.6 W.P. Campbell, M.S. *Power-Take-Off Driveline Shielding and Education Effectiveness.* May 1986.

5.7 J.M. Shutske, Ph.D. *Sensing and Controlling Fires on Agricultural Equipment.* December 1987.

5.8 T.L. Wilkinson, M.S. *Agricultural Equipment Modifications for Physically Disabled Farm Operators.* May 1987.

5.9 M.A. Purschwitz, Ph.D. *Development of a Data Collection System for Fatal and Permanently Disabling Farm Accidents.* August 1989.

5.10 T.L. Wilkinson, Ph.D. *Power-Take-Off Entanglement Risk Factor Analysis.* August 1991.

5.11 E.J. Sheldon, M.S. *Alternative Enterprises and Off-Farm Employment Options for Farmers with Physical Disabilities.* August 1992.

5.12 E.J. Sheldon, M.S. *Review and Analysis of Farm Work-Related Injuries and Fatalities Involving Children and Adolescents Through Age 17.* December 1992.

5.13 S.A. Freeman, Ph.D. *A Knowledge System for the Selection and Documentation of Rural Assistive Technology.* May 1993.

5.14 Z. You, Ph.D. *The Design of Farm-Related Accident Only Disability Income Insurance.* May 1993.

5.15 P.B. Allen, M.S. *An Assessment of the Risks and Safety Education Training Needs of Farmers and Ranchers with Severe Physical Disabilities.* August 1993.

5.16 A.J. Ploss, M.S. *An Assessment of the Accessibility of Indiana High School Agricultural Education Programs for Students with Physical Disabilities.* May 1994.

5.17 S.D. Whitman, M.S. *Preventing Tractor Related Injuries Among Aged Farmers: Using Farm Injury Data and Formative Audience to Construct Persuasive Safety Messages.* August 1994.

5.18 E.J. Sheldon, Ph.D. *CAI/Multimedia Approach to Farm Tractor and Machinery Safety Certification.* May 1995.

During the ASABE Summer Meeting in Sheboyagan, Wisconsin, Professor Field and three of his graduate students were detained for breaking into a closed, all you could eat fish bar. The door was unlocked and the sign flashed "OPEN" and before they figured out that no one was home, they were surrounded by three officers with hands on their guns. Apparently, the owner closed early but forgot to turn off the sign and lock the door, but he did, however, activate the silent alarm. No time was served, but neither was any fish.

5.19 K.W. Kelley, M.S. *Flow Characteristics of Gravity-Flow Grain Wagons Contributing to Engulfment in Flowing Grain and Possible Intervention Strategies.* December 1995.

5.20 L. Zheng, M.S. *Using Remote Controls to Improve the Accessibility to Agricultural Equipment.* January 1996.

5.21 J.J. Carrabba, M.S. *Effectiveness of Indiana 4-H Tractor Program at Instilling Safe Tractor Operating Behaviors and Attitudes in Youth.* December 1998.

5.22 N.S. Sutherlin, M.S. *Summary of Fatal Farm Work-Related Injuries to Children and Adolescents in Indiana and Wisconsin from 1970-1999.* May 2001.

5.23 D.M. Kingman, M.S. *Prevention Strategies for Flowing Grain Entrapments in On-Farm Grain Storage Bins.* May 2000.

5.24 D.M. Kingman, Ph.D. *Utilizing a Systems Approach to Develop an On-Farm Grain Storage Hazard Assessment Tool.* May 2002.

5.25 A.M. Yoder, Ph.D. *Ergonomic Evaluation of Commercially Available Operator Lifts for Farmers with Disabilities.* December 2002.

5.26 R.R. Ortega, M.S. *Analysis and Evaluation of the Effectiveness of the 4-H CAI/Multimedia Farm Tractor and Machinery Safety Certification Program.* May 2003.

5.27 S.R. Beer, M.S. *Development of a National Database Management System for Power-Take-Off Related Injuries and Fatalities.* May 2004.

5.28 J. Kunkler, M.S. *Farm-related Injuries in Amish and Old Order Communities.* December 2004.

5.29 J. Metcalf, M.S. *Enhanced Upper Limb Prosthetics for Farmers Who Have Experienced Upper Limb Loss.* May 2005.

5.30 R. Beaver, M.S. *Summary of Fatalities in Manure Storage and Handling Facilities.* May 2005.

5.31 C. Racz, M.S. *Preferences for Dissemination of Rural Assistive Technology Information.* December 2006.

5.32 S. Bullock, Ph.D. *Evaluating the Effectiveness of a Visually-Based Farm Tractor and Machinery Safety Curriculum Compared to a Text-Based Curriculum*. December 2006.

5.33 M. Roberts, M.S. *Summary of Prior Grain Entrapment Rescue Strategies and Application Principles Associated with using a Grain Rescue Tube as a Grain Retaining Device.* August 2008.

5.34 S. Mathew, Ph.D. *An Assessment Process to Estimate the Secondary Injury Potential of Assistive Technology Adopted by Farmers with Disabilities*. December 2009.

5.35 A. Mann, M.S. *Identification, Development, Validation, and Dissemination of Written Exam Items for the Agricultural Hazardous Occupations Order (AgHOs) Certification Training Program.* August 2010.

5.36 B. Hoover, Ph.D. *Evaluating the Pre-operational and Operational Test Instruments and Testing Strategies for the Gearing up for Safety: Production Agricultural Safety Training for Youth*, December 2010.

5.37 S. Riedel, M.S. *Estimation of the Frequency, Severity and Primary Causative Factors Associated With Injuries and Fatalities Involving Confined Spaces in Agriculture*. December 2011.

5.38 P.O. O'Connor, M.S. *The Economic Impact of Extending OSHA's Grain Handling Standards to Currently Exempt Agricultural Worksites*, Spring 2012.

5.39 R. Stuthridge, Ph.D. *The Consideration of Usability in the Process of Designing and Selecting Assistive Technology for Use in Agricultural Settings*, Spring 2012.

5.40 S. Snyder, Ph.D. *Identification and Validation of Agricultural Hazardous Occupation, Order Certification Program Instructor Criteria and Competencies*, Spring 2014.

5.41 S. Issa, Ph.D., *Evaluating the Impact of Forces on a Human Body While Being Rescued and Entrapped in Grain,* Summer 2015.

5.42 C. Cheng, Ph.D. *Measuring the Effectiveness of Delivery Strategies Used to Conduct an Evidence-based Grain Storage and Handling Safety Curriculum Targeted Towards Young and Beginning Workers*, Fall 2017.

5.43 S. Ehlers, Ph.D. *Rearward Visibility Issues Related to Agricultural Machinery: Contributing Factors, Potential Solutions,* Spring 2017.

5.44 M. Nour, Ph.D. *Developing and Implementing Surveillance System for Farm-related Injuries Involving Livestock Manure Storage, Handling, and Transport Equipment and Facilities with Analysis and Implications*, Fall 2020.

Professor Field has also served on graduate committed in Ireland, Sweden, and Australia.

6. Improve rural and agricultural emergency response training.

Based on Indiana data, one out of every nine farm families experiences an agricultural-related injury each year. Approximately 60 percent of these injuries require emergency medical treatment due to burns, lacerations, broken bones, concussions, eye injuries, or exposure to toxic materials. In Indiana this amounts to approximately 3,700 cases each year. Appropriate first response skills and knowledge on the part of the first responder, whether it be the farm wife, rural law enforcement personnel, member of a volunteer fire department, or emergency medical unit, is critically important to ensure the safety of the responder and minimize the extent of injury to the victim. There continues to be, however, a lack of adequately trained emergency medical services in rural areas and few farm family members have been trained in even the basics of first aid. Furthermore, less than 15% of Indiana's rural emergency medical and resource personnel have experience with farm-related operations and the possible hazards of a serious farm accident. This places both the victim and rescuer at risk of injury.

While traveling to a law enforcement training workshop on the illegal production of methamphetamine in rural Indiana, Professor Field was detained for 1½ hours following a routine traffic stop for having a car load of drug paraphernalia, including some of the ingredients to manufacture meth, all of which were part of his presentation. After that incident, he assigned transport of the methamphetamine demonstration aids to his graduate students.

During one of the workshops on grain bin rescues, a large fire fighter became stuck in the top access hatch turning the training into a real rescue. It was learned that not all fire fighters can access a 24" opening.

During the past four decades, PUASHP has provided formalized training to over 23,000 emergency medical and rescue personnel. Purdue, through an earlier contract with the Indiana Emergency Medical Services Commission, provided training for instructors to conduct

agricultural emergency training at the local level. This resulted in over 50 instructors located across the state equipped to provide local training. It is estimated that this group of instructors has provided training to over 8,000 additional individuals. In addition, efforts have been made to promote extensive first aid training to farm families and to assist them in being better prepared to respond to serious injuries.

While in route to an Extension meeting, Professor Field was involved in a high speed pursuit between an Indiana State Police officer and a speeding driver. In the process the front, rear, and driver's side of the Purdue car were damaged, including damage caused when Professor Field rammed the side of the car being chased. The damaged car made it to the Extension meeting and back to Purdue where the description of what happened required several attempts to explain.

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Recently, PUASHP has hosted intensive agricultural emergency response workshops for instructors and other emergency response personnel. Topics have ranged from machinery extrication and high rise agricultural rescue to responding to anhydrous ammonia leaks, conducting grain bin rescues, and the hazards associated with illegal methamphetamine labs. For example, between 2010 and 2014, with support from a U.S. Department of Labor grant over 4,200 first responders representing over 150 fire/rescue units received 7-hours of training on grain bin rescue strategies. In addition over 45 trainers received additional training and resources to conduct local training on grain rescue. The "train-the-trainer" approach has greatly multiplied the potential impact of the Purdue program efforts across the state. Between 2014 and 2019, an additional 2,100 first-responders participated in a three-hour introduction to grain rescue strategies.

In 2019, the National AgrAbility Project website had approximately 10,000 hits per day with over 860,000 pages of content being downloaded.

In collaboration with the Northeast Regional Agricultural Engineering Service, three editions of Responding to Agricultural Emergencies were published, with over 135,000 copies distributed to first responders nationwide. A fourth edition is currently being worked on with support from USDA/NIFA.

The program has played an important role in the development of educational materials that have targeted rural emergency first responders. This has included the publication, *Responding to Agricultural Emergencies* (NRAES 1999) (3 editions) which has sold over 135,000, copies, *Don't Go With the Flow* video (NFGA 1998), and STOP, THINK, LIVE (Posey County Farm Bureau, 2017). In 2019, funding was received to put the Responding to Agricultural Emergencies online.

In 2006, with support from Purdue's Institute for Homeland Security and the Indiana Department of Homeland Security, the program participated in the development of two graduate

level courses for professionals seeking careers in fields related to homeland security. The development team was interdisciplinary, involving faculty from Agricultural Engineering, Nursing, Computer Science, Management, and Leadership Development. To date, over 500 graduate students have enrolled in one or both classes.

7. Develop a rehabilitation technology information base and demonstrate service delivery strategies designed to enhance the independence of rural and farm families impacted by disability.

For over 37 years, the PUASH staff have reached out to farmers with disabilities attending the National Farm Machinery Show in Louisville, KY.

Professor Field began the Breaking New Ground Project (AgrAbility Project) at Purdue in 1979 to serve the needs of farmers with disabilities who desired to remain active in their farm operation despite their physical limitations. Since 1979, the project has responded to over 45,000 requests for technical information and has published a newsletter which was mailed at one time to about 13,000 individuals. Over 30 issues were published between 1980 and 2000. The program has been involved in hosting or participating in over 140 workshops for farmers and rural rehabilitation professionals held throughout the United States and Canada. Three editions of a resource manual on rural assistive technology were published containing over 700 pages of ideas to make the return to farming following a disability easier and safer. (The most frequent causes of significant disability of those contacting the Breaking New Ground Project continues to be arthritis, back injuries and traumatic injuries.) An extensive CD catalogue of assistive technology (The Toolbox) with full color photos and video clips was completed with over 17,000 copies of the CD version of The Toolbox distributed nationally. The complete contents of The Toolbox is now online, available at www.agrability.org. This site receives approximately 11,000 hits per day with over 860,000 page views per year. One of the program's most popular products is a publication, *Arthritis and Agriculture* which was done in collaboration with the Arthritis Foundation – Indiana Affiliate. Over 100,000 copies of this resource have been distributed nationally. Follow-up publications on living with arthritis in the Amish/Old Order, gardening with arthritis, and on back impairments in agriculture were recently released.

Professor Field invested $14,000 to purchase one of the first Apple computers in the Department of Agricultural and Biological Engineering. It was used to develop the first known database of assistive technology for farmers. The computer was presented to retiring Professor Huggins for use as an anchor for his new boat.

The Breaking New Ground Resource Center operating within the PUASHP has received the top diversity award from Purdue University, State of Indiana, U.S. Department of Labor, U.S. Department of Agriculture, RESNA, and the National Safety Council.

The Breaking New Ground Resource Center and the National AgrAbility Project have become the most widely recognized sources of community educational material related to rural assistive technology issues and working with farm families impacted by

disability. The following is a sample of resources that have been produced and accessible at the AgrAbility website.

7.1 *Rehabilitation Technology — "A Challenge for All,"* 13-minute video presentation, 1986.

7.2 *Modified Agricultural Equipment: Manlifts for Farmers & Ranchers with Physical Handicaps*, 1987.

7.3 *Arthritis and Farmers*, 15-minute video presentation, 1989.

7.4 *Agricultural Tools, Equipment, Machinery & Buildings for Farmers & Ranchers with Physical Disabilities*, 1986, 1991, 2000.

7.5 *Conducting Agricultural Worksite Assessments*, 1991.

7.6 *Assistive Technology Needs Assessment of Farmers and Ranchers with Spinal Cord Injuries*, 1992.

7.7 *Identifying, Selecting, and Implementing Assistive Technology in the Agricultural Workplace*, 1992.

7.8 *Making Career Decisions Following a Disability — A Guide for Farmers & Ranchers*, 1992.

7.9 *Rural Assistive Technology Slide Presentation Resource*, 134 slide presentation with descriptions, 1992.

7.10 *Enterprising Ideas*, 1993.

7.11 *Improving Your Rural Business with the ADA*, 1993.

7.12 *Improving Farmstead Accessibility*, 1994.

In 2018, the PUASHP received the Partner of the Year Award from the National Black Farmer's Association for its outreach to disabled farmers.

7.13 *Cooperative Extension Service and Accessibility*, 15-minute video presentation/ package, 1995.

7.14 *Farming with an Upper Extremity Amputation*, 23-minute video presentation, 1995.

7.15 *National AgrAbility Project*, 15-minute video presentation, 1995.

7.16 *To Everything there is a Season*, 48-minute video presentation/package for rural caregivers, 1996.

7.17 *Barn Builders*, 1996, 2002.

7.18 *The Toolbox CD*, 2004, 2007, 2009.

7.19 *Arthritis and Agriculture*, 2004.

7.20 *Plain Facts about Arthritis*, 2005.

7.21 *Conducting Agricultural Worksite Assessments*, 2010.

7.22 *Back on the Farm, Back in the Saddle*, 2014.

7.23 *Arthritis and Gardening*, 2016.

In addition, the Breaking New Ground Resource Center has produced over 25 technical reports on specific disability-related issues that have been distributed to thousands of individuals throughout North America. These include:

7.1 Tormoehlen, R. L. and Field, W. E., 1983. No. 1. *Potential Health and Safety Risks of Farming with Physical Handicaps.* Breaking New Ground Newsletter, Vol. 1, No. 4, Purdue University.

7.2 Gaynor, R., Willkomm, T.M., and Field, W. E., 1986. No. 2. *Hand Controls for Agricultural Equipment.* Breaking New Ground Newsletter, Vol. 4, No. 2, Purdue University.

7.3 Willkomm, T. M. and Field, W. E., 1986. No. 3. *Prosthetic and Worksite Modifications for Farmers with Upper Extremity Amputations.* Breaking New Ground Newsletter, Vol. 4, No. 3, Purdue University.

7.4 Richey, C. B. and Field, W. E., 1986. No. 4. *Purdue Designed Chairlift Attachments for Farmers with Restricted Mobility.* Breaking New Ground Newsletter, Vol. 4, No. 4, Purdue University.

7.5 Hancock, J. N. and Field, W. E., 1987. No. 5. *Selection and Operation of All-Terrain Vehicles by Physically Impaired Farmers.* Breaking New Ground Newsletter, Vol. 5, No. 3, Purdue University.

7.6 Hancock, J. N. and Field, W. E., 1989. No. 6. *Farming Following a Spinal Cord Injury.* Breaking New Ground Newsletter, Vol. 7, No. 1, Purdue University.

7.7 Field, W. E., 1989. No. 7. *Rehabilitation Services - A Challenge for Rural America.* Breaking New Ground Newsletter, Vol. 7, No. 2, Purdue University.

7.8 Bowles, J. W. and Field, W. E., 1990. No. 8. *New Concepts in Manlift Attachments for Tractors and Combines.* Breaking New Ground Newsletter, Vol. 8, No. 1, Purdue University.

7.9 Linville, B. T., Brusnighan, D. A., and Field, W. E., 1990. No. 9. *Improving Worksite Mobility for Farmers with Physical Disabilities.* Breaking New Ground Newsletter, Vol. 8, No. 2, Purdue University.

7.10 Clemons, N. M., 1991. No. 10. *Alternative Farm Enterprises for Farmers with Disabilities.* Breaking New Ground Newsletter, Vol. 9, No. 1, Purdue University.

7.11 Brusnighan, D. A. and Field, W. E., 1991. No. 11. *Guidelines for Construction of Ramps Used in Rural Settings*. Breaking New Ground Newsletter, Vol. 9, No. 2, Purdue University.

7.12 Deason, M., 1991. No. 12. *Directory of Rural Assistive Technology Resources.* Breaking New Ground Newsletter, Vol. 9, No. 3, Purdue University.

7.13 Carpenter, R. and Deason, M., 1991. No. 13. *Farming with a Visual Impairment.* Breaking New Ground Newsletter, Vol. 9, No. 4, Purdue University.

7.14 Tormoehlen, R.L., 1992. No. 14. *A Perfect Fit - Involving Youth Who Have Disabilities.* Breaking New Ground Newsletter, Vol. 10, No. 1, Purdue University.

7.15 Deason, M., Kirkpatrick, E., and Field, W. E., 1992. No. 15. R*ural Public Libraries - A Resource for the Disabled.* Breaking New Ground Newsletter, Vol. 10, No. 2, Purdue University.

7.16 Sillery, B. and Allen, P. B., 1992. No. 16. *Assistive Communication Devices for Farmers/ Ranchers with Physical Disabilities.* Breaking New Ground Newsletter, Vol. 10, No. 3, Purdue University.

7.17 Frederick, C. and Field, W. E., 1993. No. 17. *Farming/Ranching with Cerebral Palsy.* Breaking New Ground Newsletter, Vol. 11, No. 2, Purdue University.

7.18 McCormick, S., 1993. No. 18. *Reins of Life - Riding for the Disabled.* Breaking New Ground Newsletter, Vol. 11, No. 3, Purdue University.

7.19 Yearns, M. and Brusnighan, D.A., 1994. No. 19. *Making Your Farmhouse Accessible.* Breaking New Ground Newsletter, Vol. 12, No. 1, Purdue University.

7.20 McVea, T. Z., Freeman, S. A., and Sheldon, E. S., 1994. No. 20. *Farming with a Respiratory Impairment.* Breaking New Ground Newsletter, Vol. 12, No. 2, Purdue University.

7.21 Delks, B., McLeod, W., Baker, D., and Williams, W., 1995. No. 21. *Computer Utilization by Farmers with Disabilities.* Breaking New Ground Newsletter, Vol. 13, No. 1, Purdue University.

7.22 Breaking New Ground Staff, 1995. No. 22. *Directory of Rural Assistive Technology Resources.* Breaking New Ground Newsletter, Vol. 13, No. 2, Purdue University. (Replaces Plowshares No. 12).

7.23 Getts, M. L., Ploss, A. J., and Brusnighan, D. A., 1995. No. 23. *Farming with a Hearing Impairment* Breaking New Ground Newsletter, Vol. 13, No. 3, Purdue University.

7.24 Petrea, C., Brusnighan, D. A., and Schweitzer, J. M., 1996. No. 24. *Farming with a Lower Extremity Amputation or Impairment.* Breaking New Ground Newsletter, Vol. 14, No. 1, Purdue University.

7.25 Newman, M.C., Field, W. E., and McCormick, S., 1996. No. 25. *Accessing Horses and Horse Drawn Vehicles.* Breaking New Ground Newsletter, Vol. 14, No. 2, Purdue University.

7.26 Gruver, M.L., Tyring, T., Field, W. E., and Weisman, G., 1997. No. 26. *Farming with a Back Impairment.* Breaking New Ground Newsletter, Vol. 15, No. 1, Purdue University.

7.27 Gruver, M. L., Allen, P. B., Field, W. E., and Schweitzer, J.M., 1997. No. 27. *Potential Health and Safety Risks of Farming/Ranching with a Disability.* Breaking New Ground Newsletter, Vol. 15, No. 2, Purdue University.

7.28 Ehlers, S.G., Stuthridge, R.W., Field, W.E., Geng, Q., and Smith, J., 2017. *Adaptive Hand Controls for Agricultural Machinery*. Breaking New Ground Newsletter, Purdue University.

7.29 Ehlers, S.G., Field, W.E., Geng, Q., and Smith, J., 2018. *Lighting for Farmsteads and Self-propelled Agricultural Machinery*. Breaking New Ground Newsletter, Purdue University.

The BNG Resource Center worked in partnership with the National Easter Seals to provide leadership to the USDA National AgrAbility Project during the first 10 years of the program's operation (1991-2000). This involved providing resources and training to over 70 staff involved with the 21 state projects. Since 1990, the Breaking New Ground Outreach Program has served as the Indiana component of the USDA AgrAbility Program providing direct services to farm families and information dissemination throughout the state. After eight years at the University of Wisconsin, the National AgrAbility Project returned to Purdue in 2008 in partnership with Goodwill International and the Arthritis Foundation-Heartland Chapter. This effort is funded through 2021 in partnership with Goodwill of the Finger Lakes and Associated Programs of Rural Independent Living (APRIL).

Since 1979, over $18.5 million have been raised to support the work of the Breaking New Ground Resource Center to serve the needs of farm families impacted by disabilities throughout the U.S. and internationally.

Special initiatives of the National AgrAbility Project currently are efforts to reach out to special populations, including socially disadvantaged and black farmers and returning veterans with disabilities, and to expand the impact of AgrAbility internationally. Since 2011, with support from funding received from the Dean's Team Award, AgrAbility programming has been conducted in the Ukraine, Sweden, Ireland, Finland, Denmark, Wales, Austria, Canada, Italy, Norway and at several international conferences such as the World Food Prize Conference. Currently, support is being given to establish AgrAbility for Africa with an event scheduled for 2020.

Distributed Research Reports

Introduction

In 1982, Roger Tormoehlen received his M.S. specializing in the area of agricultural safety and health. Thirty seven years later, his son, Sean, received his M.S. in the same field.

Graduate level research conducted by research assistants working with the PUASHP has resulted in findings that have been used by professionals working in the field to enhance the efficacy of agricultural safety and health efforts. The extensively reviewed literature, research methods, presentations of research data, conclusions, recommendations and bibliographies offer valuable tools for completing additional research or developing new strategies for preventing agricultural-related injuries and losses. Several of the researchers are now employed full time in the agricultural safety and health profession. The following are the abstracts for some of the research conducted.

Research Reports

Sell, W.E. 1984. **The Nature of Power Take-Off Accidents.** Master of Science.

Abstract: Review of literature concerning farm injury data, the frequency of PTO-related injuries, types of injuries, role of shielding in PTO accidents, machines involved in PTO accidents, standards for PTO equipment, and an overview of the development of PTO equipment. Presentation of data collected in a study conducted of 64 non-fatal power takeoff accidents covering the human factors associated with the accidents, the environmental conditions at the time of the accidents, the machines involved in the accidents, and selected case histories. Evaluation of PTO master shield usage on 578 John Deere tractors and 279 other makes of farm tractors. Evaluation of PTO pictorial warning decals. Summary, conclusions, observations, recommendations and a bibliography.

Campbell, W.P. 1987. **The Condition of Agricultural Driveline System Shielding and Its Impact on Injuries and Fatalities.** Master of Science.

Abstract: Review of literature concerning the history of the power takeoff, studies of non-fatal and fatal power takeoff injuries, studies of the condition of power takeoff component shielding, and a review of power takeoff safety signs. Presentation of data collected in a study involving 100 non-fatal power takeoff injuries (includes the 64 reported on by Sell, 1984), covering the human factors associated with the injury, the environmental conditions, the machinery involved, and the injuries received by the victims. Presentation of data collected in a study of 25 fatal power takeoff accidents covering the human factors associated with the accidents, the environmental conditions at the time of the accidents, the machinery involved in the accidents, and the cause of death of the victims. Summary of a detailed investigation of power takeoff component shielding on 1,309 agricultural implements, including examination of the implement input driveline (IID) shielding, implement input connection (IIC) shielding, and pedestal shielding. Investigation of the presence of safety signs on the power takeoff driveline and components during the investigation of the condition of shielding on agricultural implements. Discussion, recommendations, observations, and a bibliography.

Wilkinson, T.L. 1987. **Evaluation of Self-Propelled Agricultural Machines Modified for Operators with Serious Physical Handicaps.** Master of Science.

Abstract: The primary goal of this study was to identify and evaluate modifications made to self-propelled agricultural machines for farmers and agricultural workers with serious physical handicaps, and to document results for use by rehabilitation professionals. The study, with funding from the Department of Education's National Institute of Handicapped Research, involved the following major activities: (1) evaluation of 29 self-propelled agricultural machines equipped with modifications for physically disabled operators; (2) a survey of 500 farmers and agricultural workers with physical disabilities to identify modifications allowing them to operate essential agricultural machines; (3) site-visits to 17 farms to evaluate machine modifications and interview farmers with physical disabilities. A direct product of this research project was the publication of the resource manual, *Modified Agricultural Equipment: Manlifts for Farmers with Physical Handicaps*.

Shutske, J.M. 1988. **Prevention and Suppression of Self-Propelled Grain Combine Fires.** Doctor of Philosophy.

Abstract: Review of literature concerning the problem of combine fires, theories of fire extinguishment, fire extinguisher research, and mathematical modeling in fire protection. Nature and magnitude of the combine fire problem through investigations of 50 combine fires and the summary of 122 Indiana combine fires, case studies, and the National Fire Incident Reporting System Data. Combine fire modeling Fire extinguisher tests on a combine using Halon 1211 and ABC dry chemical extinguishing agents with the use of fire detectors. Conclusions, recommendations, and a bibliography.

As part of this Ph.D. research, John Shutske set fire multiple times to a combine donated to PUASHP by International Harvester for him to explore various strategies for extinguishing fires. His "international" burning of a $100,000+ combine ended up receiving a demand for an explanation from the President's office.

Purschwitz, M.A. 1989. **Development of a Data Collection System for Farm-Related Accidents Resulting in Injury.** Doctor of Philosophy.

Abstract: Review of literature on farm accident data collection and the need for data. Identification of additional farm accident data sources. Summary and evaluation of current sources of farm accident data. Summary and evaluation of general occupational injury surveillance systems. Summary and evaluation of non-occupational injury surveillance systems. Summary and evaluation of health care system reporting. Opinions and preferences on farm accident data collection and management from a survey of 63 Extension specialists and Farm Bureau personnel, and 41 individuals selected from the NIFS membership list including: insurance representatives, consultants, retired safety specialists, and industry engineers. Development of a coroner and police reporting form for farm accidents. Review of a volunteer farm accident clipping program. Development of a hospital-based injury surveillance system. Denominator data: farm population. Data management: Development of personal computer database management program and procedure to code data into a common format for entry. Application of the data management system with the use of Indiana farm accident data. Conclusions, recommendations, future research needs, and state and national initiatives.

In 2019, Professor Purschwitz retired after a 30+ year career working in the field of agricultural safety and health in South Carolina, Wisconsin, and Kentucky.

Wilkinson, T.L. 1991. **Power Take-Off Entanglement Risk Factor Analysis for Grain Augers.** Doctor of Philosophy.

Abstract: This study was completed to develop an expert system model to assist PTO driven grain auger manufacturers in identifying the risk factors associated with their equipment and to educate farmers on their risk of being involved in a PTO entanglement. The development of the expert system involved a five step process which included: 1) Identification of the problem, 2) Conceptualization of the problem, 3) Formalization of the knowledge, 4)

Implementation, and 5) Testing of the model. A review of literature and the summarization of a database containing 150 PTO entanglement investigations that have been completed by Purdue researchers since 1982 identified grain augers as being most commonly involved in PTO entanglements. A summarization of 53 auger and elevator PTO entanglements from the Purdue database was completed to identify the risk factors associated with the use of this equipment. These risk factors were used in developing the computer model. Description of expert system is provided.

Sheldon, E.J. 1992. **Review and Analysis of Fatal and Nonfatal Farm Work-Related Injuries Involving Children and Adolescents Through Age 17.** Master of Science.

Abstract: From farm injury records collected in Indiana and Wisconsin, a total of 460 fatal farm work-related injuries were identified during a 21-year period (1970 — 1990). Records obtained from the National Safety Council collected through a 31-state survey included 756 injuries involving children through age 14 — all but four were nonfatal. Results showed a steady decline in the frequency of fatal injuries to children and adolescents over time. A shift in the causes of fatal injuries was also observed. Very young children tended to be injured by tractor and equipment run overs, while older children were more likely involved in tractor rollovers. Run overs became much more common in the later years of the study and tractor rollovers declined by nearly twice the frequency of all other fatal injuries. It was concluded that a more precise method of obtaining farm injury data, particularly from nonfatal injuries, would enable researchers and farm safety specialists to better understand the causes of farm injuries to children. Additional attention should be given to educational programs which focus on parents of young children and stress the dangers associated with exposure to farm machinery, especially as extra riders on tractors.

Professor E.J. Sheldon served as Chair of the Department of Occupational Safety and Health at Indiana State University.

Sheldon, E.J. 1992. **Alternative Enterprise and Off-farm Employment for Farmers with Disabilities**. Master of Science.

Abstract: The purpose of this study was to examine off-farm employment opportunities and explore the feasibility of farm-based alternative enterprises for farmers who have experienced permanent physical disabilities. Two major approaches were utilized in this research. First, a mail survey concerning off-farm employment and alternative enterprises was sent to 1700 farmers with physical disabilities on the Breaking New Ground Resource Center mailing list. Second, on-site visits were conducted with over 50 selected farmers with physical disabilities to determine their experiences with off-farm employment and alternative enterprises, and to develop successful case histories. Both off-farm employment and alternative enterprises were shown to be viable income producers for farmers with physical disabilities. Thirty-seven percent of the 42 farmers returning the survey have looked for off-farm employment since their disability, and twenty-nine percent reported having an off-farm job. The most serious barriers to off-farm employment for the surveyed group included the severity of disability and the lack of local jobs. Twenty-seven percent of the participating framers reported having some type of alternative on-farm enterprise which contributed to

family income, with forty-one percent indicating starting or expanding alternative enterprises.

Freeman, S.A. 1993. **A Knowledge System for the Selection and Documentation of Rural Assistive Technology.** Doctor of Philosophy.

Abstract: A prototype knowledge system for the selection and documentation of rural assistive technology was developed to aid professionals working with farmers, ranchers, and agricultural workers with physical disabilities. The knowledge system (constructed using HyperCard, an object-oriented-like environment that combines hypertext and database features) consists of a hypertext database of rural assistive technology examples and an accompanying decision support system that helps users identify solution alternatives to meet the needs of their clientele. The usefulness of this knowledge system as a novel delivery method for presenting rural assistive technology information to extension personnel and rehabilitation professionals was tested and evaluated by a group of representative end users (U.S. Department of Agriculture's AgrAbility staff members). This was done using a statistical control group study (consisting of two test cases) and an evaluation questionnaire. Using the knowledge system significantly reduced the time required for end users to obtain solution alternatives and increased their confidence in the solutions they obtained. All of the questionnaire respondents considered the system to be easy to use, practical for real life use, and useful as an educational aid. Additionally, the response was unanimous that the knowledge system should be completed and distributed to the programs providing rehabilitation services to farmers, ranchers, and agricultural workers.

Professor Freeman served as Assistant to the President at Iowa State University.

Ziyou, Y. 1993. **The Design of Farm-Related Accident Only Disability Income Insurance**. Doctor of Philosophy.

Abstract: The general objective of this research was to develop Farm Work-Related Disability Income (FWDI) insurance policies which will appeal to farmers and agricultural workers while allowing the insurance companies involved to at least break-even. Modern mathematical models in insurance are reviewed and applied to develop the optimal insurance coverage for FWDI insurance. The moral hazard problem in insurance is controlled by "incomplete coverage." The income loss due to a farm work-related injury is defined as wage per day times the number of days lost due to the injury. By analyzing two data sets (the National Safety Council 1982 farm accident survey results and the 1990 Ohio agricultural Workers Compensation claims) with the direct probability approach and the econometrics modeling approach, the farm work-related injury factors were determined; the loss distribution of farm work-related injuries and the cost of FWDI insurance policies were estimated. A survey designed to determine the acceptance of the FWDI insurance policies was conducted. It was found that farmers prefer to pay $130 per year for disability income insurance with 30 days deductible and $300 weekly compensation.

Allen, P.B. 1993. **An Assessment of the Risks and Safety Education Training Needs of Farmers and Ranchers with Severe Physical Disabilities.** Master of Science.

Abstract: The purpose of this study was to determine the perceived risks, and educational training needs of those individuals who are farming or ranching with a physical disability. The study was also designed to explore whether or not a farmer or rancher with a physical disability is at greater risk of injury than his or her able-bodied counterpart. A survey titled "Risks of Farming and Ranching with a Physical Disability" was developed and administered to 1,954 farmers and ranchers known to have a severe physical disability. Twenty-five percent of the respondents have had a farm-related injury they believed was the result of their physical disability. Most secondary injuries were livestock-related, primarily beef cattle. Falls were noted as the second most prevalent cause of injury, followed by hand and power tools. The survey found that non-fatal farm-related injuries of farmers with physical disabilities tended to mirror farm-related injuries of able-bodied farm operators except for the higher incidence of bruising and pressure sores occurring among the population with spinal cord injuries. The survey found that 60 of the respondents believed they were at a greater risk of being injured in their farm or ranch because of their physical disability. The findings in this study indicate a need for educational safety training to reduce the rate of injury.

Whitman, S.D. 1994. **Preventing Tractor Related Injuries Among Aged Farmers: Using Farm Injury Data and Formative Audience Analysis to Construct Persuasive Safety Messages.** Master of Science.

Abstract: The principal goal of this research was to develop guidelines for constructing persuasive safety messages to reduce tractor-related injuries and fatalities among senior agricultural workers. Formative research of the safety-related attitudes, beliefs, and activities of farm workers age 60 and older was utilized to develop guidelines for designing persuasive safety messages and communication tools most likely to facilitate the adoption of self-protective work behaviors among senior tractor and machinery operators. The central activities of this thesis work consisted of 1) preparing a summary of farm tractor and machinery-related fatalities involving senior farm workers, and 2) conducting a national survey of senior farmers (age 60 and older). The final phase of this work involved developing guidelines for designing safety messages and communication tools for reducing tractor-related injuries and fatalities among senior farmers. Guidelines were based on formative survey research and applicable principles of behavioral change and persuasion theory identified in the research literature. Guidelines include recommendations to assist safety practitioners, Extension specialists, and farm media professionals in designing and presenting farm safety messages to the senior farmer audience.

Sheldon, E.J. 1995. **CAI/Multimedia Approach to Farm Tractor and Machinery Safety Certification.** Doctor of Philosophy.

Abstract: The primary goal of this project was to develop and demonstrate the educational effectiveness of a CAI/Multimedia computer program for use by youth enrolled in the Farm Tractor and Machinery Safety Certification Programs presently prescribed by the United States Department of Labor Hazardous Work

At one time, two graduate students in the PUASHP were identified as E.J. Sheldon. Ernie became a faculty member at Indiana State University, while Ed currently is employed by the PUASHP.

Occupations in Agriculture Order. The computer program was based on Silletto and Hull's "Safe Operation of Agricultural Equipment" students' manual, currently the most widely-used material for teaching the course. Seventy-two subjects from three agricultural education classes and one group assembled at Purdue University were randomly divided with half of each group receiving traditional instructor-based training using printed text, videos, and demonstrations, and half receiving self-instruction using the computer program. All subjects were administered a participant questionnaire and pretest prior to their assignment to instruction method. Following completion of the 11 unit course, all subjects were administered a post test. Those subjects who had received computer-based instruction then completed a multimedia perception questionnaire. There was no significant difference in mean knowledge gain between instructional methods. Level of previous experience in tractor and machinery operation did not affect pretest or post test scores. Among those subjects in the computer-based group, level of computer experience did not affect pretest or post test scores. It was concluded that the CAI/Multimedia program did provide adequate instruction in safe operation of agricultural equipment since no significant difference in mean knowledge gain existed.

However, it was recommended that further research was needed to determine whether hands-on experience available only through the traditional method would improve operator skills and improve the retention of knowledge gained.

Kelley, K.W. 1995. **Flow Characteristics of Gravity-Flow Grain Wagons Contributing to Engulfment in Flowing Grain and Possible Intervention Strategies.** Master of Science.

Abstract: The principal goal of this research was to develop intervention strategies that would potentially reduce the likelihood of fatal entrapments in gravity-flow grain wagons. A nationwide study of fatal farm work-related grain entrapments was initiated to quantify the problem of on-farm grain entrapments, to identify high risk groups, and to gain information that might enable the development of more effective intervention strategies. The study identified 235 incidences from 1964 through 1994. The incidences were identified in 23 states and in the Canadian province of Ontario. Grain transport vehicles were reported to be involved in 39 cases. Full-scale gravity-flow grain wagon experiments were conducted using a 7-8 year old female mannequin, three intervention design configurations — (1) no insert present, (2) solid (grate) insert, (3) and split outlet insert; and corn at 15-21% moisture content (wb) as the medium. Model wagon trials were conducted to characterize flow patterns that develop when grain exits a side-dump gravity-flow wagon, with and without a flat plate insert present. The thesis includes recommendations concerning the cost of a national retro-fit program, as well as measures to prevent future entrapments, and topics for additional research.

Carrabba, J.J. 1998. **Effectiveness of the Indiana 4-H Tractor Program at Instilling Safe Tractor Operating Behaviors and Attitudes in Youth.** Master of Science.

Abstract: The purpose of this research was to determine what impact the Indiana 4-H Tractor Program has on the safe tractor-operating behavior and attitudes of its participants. Results of the research showed that the program has a positive influence, however, there is also room for improvement. To assess the impact of the program, a group of 108 non 4-H youth that operate tractors and a group of 104 4-H Tractor Program participants were

compared. The two groups were observed operating a tractor through a standard tractor-operating course and the safe tractor operating behaviors of each group were compared. Results of these observations showed that the 4-H Tractor Program participants operated tractors in a safer manner than the non 4-H Tractor Program youth. The self-reported tractor-related injury history and tractor safety attitudes of the two groups were also compared through the use of a written survey. Results of the survey found that the 4-H Tractor Program participants reported more exposure time to tractors. There was little difference between the two groups in regard to tractor-related injuries and tractor safety attitudes. Responses from the 4-H Tractor Program participants indicated a trend towards having more tractor-related close call incidents. A mail survey of past participants of the Indiana State 4-H tractor-driving contest was also conducted. The purpose of this survey was to gather feedback on the Indiana 4-H Tractor Program. There were 126 respondents to this survey for a 65.6% response rate. Respondents reported positive impressions of their experiences in the Indiana 4-H Tractor Program. Suggestions for improving the program were collected from this survey.

Kingman, Douglas, M., 1999. **Prevention Strategies For Flowing Grain Entrapments In On-Farm Grain Storage Bins.** Master of Science.

Abstract: A study was conducted to develop strategies that would contribute to the prevention of fatalities and injuries that occur in on-farm grain bins due to flowing grain engulfments. The study of fatalities consisted of a review of data summarized from known entrapment cases and from the initiation of a national search for additional cases. Cases documented were summarized to identify a target audience and potential contents for the development of a prototype flowing grain entrapment curriculum and recommendations for engineering intervention strategies. During the years 1964 to 1998, 181 entrapment fatalities were identified that occurred in on-farm grain bins. It was estimated that at least five farm workers or children die annually in grain bins after becoming entrapped in flowing grain. There was evidence to suggest that non-fatal entrapments also regularly occurred and were not reported or identified by previous surveillance efforts. The phenomenon appeared to be concentrated in the major corn-producing states. 24% of the identified victims were 3 to 15 years old, while 31% of the victims were 56 to 86 years of age. Children under the age of 16 died most often in June, August and November, while adults suffocated more often in January and November. 96% of the victims were male. Stored corn was involved in 53% of the cases where the type of grain was identified. For the cases where the activity of the victim was noted during the entrapment, 76% were unloading grain. It was determined that out-of-condition grain was the most commonly identified causative factor. A prototype version of the on-farm flowing grain entrapment curriculum developed as part of the study was based upon a review of existing educational resources, examination of specific engulfment cases, visits to entrapment sites, and discussions with agricultural safety experts, and first-response personnel. Portions of the curriculum were field tested with audiences at extension events, Purdue University farm employees, and students enrolled in Purdue's Agricultural Safety and Health class. Recommendations concerning engineering intervention strategies were presented to key manufacturers of grain storage structures for feedback. These recommendations included the need to explore issues related to confined space entry, to reduce the potential for grain spoilage, and to reduce the level of accessibility for children.

Sutherlin, Natalie S. 2001. **Summary of Fatal Farm Work-Related Injuries to Children and Adolescents in Indiana and Wisconsin from 1970-1999.** Master of Science.

Abstract: The purpose of this study was to determine the frequency and causality of farm work-related fatalities involving children and adolescents age 17 and younger in Indiana and Wisconsin from 1970 to 1999. Using the Farm and Agricultural Injury Classification (FAIC) Code, 536 cases in Indiana and Wisconsin were selected for analysis. Cases were analyzed to determine frequency, cause of injury, and primary agent and to identify trends over the decades 1970-1999. Findings show there has been a steady decline in the frequency of fatal farm work-related injuries to children and adolescents in Indiana and Wisconsin during the 30-year period analyzed. Ages two and 15 were the most common ages of fatalities. The frequency of tractor rollover fatalities decreased from 77 fatalities in the 1970s to 14 fatalities in the 1990s. The frequency of tractor and equipment run overs also decreased from 78 fatalities in the 1970s to 45 fatalities in the 1990s. However, the proportion of all fatalities related to run overs nearly doubled. Recommendations resulting from the study included the need to increase the emphasis on the hazards associated with extra riders on agricultural tractors and equipment and provide direct safety information to the parents of small children living on farms concerning potential areas of risk.

Kingman, Douglas, M., 2002. **Utilizing a Systems Approach to Develop an On-farm Grain Storage Hazard Assessment Tool.** Doctor of Philosophy.

Abstract: The goal of this research was to address the problem of engulfments in flowing grain that occur in on-farm metal grain storage bins. This was accomplished by utilizing a systems approach to identify contributing factors to engulfment which were used to develop a 28-question hazard assessment tool. A numerically weighted high- and low-risk response accompanied each question, the sum of which resulted in a potential-risk-of-engulfment score for on-farm grain handling and storage systems. The assessment tool was pilot tested using nine farms where previous engulfment incidents had been reported and nine farms with no history of engulfment. A revised version was used to score an additional 26 farms with unknown histories of engulfment and by three individuals personally familiar with prior engulfment incidents. It was found that the difference between the mean of the assessment tool scores of farms with a history of engulfment and the mean of the scores of farms with no prior reported engulfment incident was significant ($p=0.001$). It was found that the management of grain during storage and an individual's perception of risk and willingness to avoid flowing grain hazards had the most impact on reducing the potential for an engulfment. In contrast, a history of plugging problems resulting from out-of-condition grain was not found to make a considerable difference in scores between the two groups of farms. The presence of stirring devices in bins, accommodation for lockout devices on electrical controls, and utilizing grain storage bins smaller than 20,000-bushel capacity also had little impact on the difference in scores. Based upon the level of significance of each of the 28 questions' ability to predict an increased risk of engulfment, it was concluded that a valid response could be obtained with as few as seven questions. Recommendations

The first commercially available grain rescue tube was developed and tested by Doug Kingman, a Ph.D. student in the PUASHP. Units have been sold across the country, Australia, Canada, and Argentina.

concerning continued study and application of the tool were formulated including the need for additional research to evaluate the effectiveness of the tool to change the behavior of farmers who own and operate grain handling and storage equipment. Findings also contributed to the revision of a potential engineering standard for on-farm grain storage structures.

Yoder, Aaron M., 2002. **Ergonomic Evaluation of Commercially Available Operator Lifts for Farmers with Disabilities.** Doctor of Philosophy.

Abstract: Individuals in the agricultural population who are impacted by mobility restrictions resulting from strokes, arthritis, amputations, back injuries, and other medical conditions are capable of safely returning to work through the appropriate application of assistive or rehabilitation technology. The purpose of this study was to develop and administer a systems approach for evaluating ergonomic and safety issues related to the application of commercially available operator lifts used on agricultural and other off-road machinery to provide a means for operators with restricted mobility to gain access to the operator's station. Input from operator lift users, objective analysis and a panel of experts were used to gain a clearer perspective of commercially available operator lift systems. Unstable seats, awkward transfers and the need for fall arresting devices were identified as concerns through on-site visits of operator lift users. Objective analysis methods, including the use of an operator lift users' questionnaire, were used to identify key issues, such as usability of the operator lift controllers and using the operator lifts in emergency situations, which needed to be addressed. An expert panel used lift evaluation tools to identify problems with installation, wiring and troubleshooting related to operator lift systems. Based upon feedback from 60 operator lift users, spinal cord injuries were reported by 42 (75%) of the users. 43 (76%) of the users had full use of their upper arms. Only nine (17%) of the lift users were able to access the same piece of machinery after their injury and before they had a lift. Eight (16%) of the 49 individuals that purchased a commercially manufactured lift reported a minor injury or near injury while using their lift. Similarly, one (14%) of the seven individuals that had a locally manufactured or homemade lift reported a minor injury while using their lift. Even though it appeared that the level of safety was the same for commercially manufactured and locally fabricated lifts, commercially manufactured lifts appeared to have fewer hazards associated with them. The findings from this study can be used to justify the safety and applicability of operator lifts in agriculture, aid in the design and fabrication of future operator lifts, and develop an industrial standard on the design, fabrication and testing of operator lifts for use on off-road equipment.

Ortega, R.R., 2003. **Analysis and Evaluation of the Effectiveness of the 4-H CAI/Multimedia Farm Tractor and Machinery Safety Certification Program.** Master of Science.

Abstract: The purpose of this research was to evaluate the effectiveness of an interactive CD-ROM and World Wide Web (WWW) educational program, entitled Gearing Up for Safety: Production Agricultural Safety Training for Youth, to teach teenaged youth critical production agricultural safety and health-related competencies required under the Fair Labor Standards Act: Hazardous Occupations Order in Agriculture. The selected community-based teaching strategies were evaluated and compared for their effectiveness in developing knowledge, changing attitudes and behaviors and improving practices related to the safe operation of agricultural tractors and machinery.

The new curriculum was based upon a set of critical core competencies developed by the researchers and an expert panel of various stakeholders chosen for their personal interest and expertise in the areas of agricultural safety and agricultural education. A comparative field test between the computer-based curricula (CD-ROM and WWW) and a traditional instructor-based curriculum was conducted in the fall of 2002. Six geographically diverse Indiana high school agricultural science and business classrooms were used for the comparative field tests. Classrooms were divided randomly into thirds with one-third of the students receiving instruction via CD-ROM, a third receiving instruction via the WWW, and a third with a teacher in the classroom using a traditional method of instruction.

The study found there was not a significant difference in knowledge gained or change in attitudes and behaviors between students using the CD-ROM, the WWW or those learning in a traditional classroom setting. Additional findings showed that youth who participated in the computer-based curriculum had a positive attitude towards computers and their role in education. It was concluded that the new interactive curriculum was an effective method for teaching youth critical health and safety topics related to production agriculture and changing both attitudes and behaviors.

Beer, S.R. 2004. **Development of a Data Management System for the Analysis of Power Take-Off Related Injuries and Fatalities.** Master of Science.

Abstract: Unguarded agricultural power take-off (PTO) drivelines and related components, including secondary drivelines powered by the PTO, have been historically recognized as serious farm-related hazards that can cause severe, permanently disabling injuries and death when entanglement occurs. The lack of longitudinal data on these incidents has been a barrier for developing relevant and effective intervention strategies. The purpose of this study was to design, develop, and test a system to document, code, store, and analyze a large amount of PTO-related injury and fatality data to allow for identification of causative factors and trends that could be used in developing more effective intervention strategies. This was accomplished by first developing a standardized injury reporting form and coding system and then developing an electronic database, using Microsoft® Access 2002, which could be used to document, store, query, and analyze PTO-related incident data. PTO-related incidents resulting in injury or fatality that were documented between 1970 and 2003 were collected and the available data were coded and entered into the database using a systematic approach. A pilot-test of the usability of the database was conducted on data collected from 92 PTO-related incidents involving children and adolescents. A summary of the findings are included. Using the validated data management system, an analysis was conducted on data collected from 674 cases entered into the database. It was determined that the data management system provided a consistent means of storing and analyzing data related to PTO-related incidents. Findings from the analysis of the data included the following: the frequency of PTO-related incidents increased from the 1970s to the 1980s, but then decreased through the 1990s and into the 2000s; PTO-related fatalities accounted for approximately 3.5 percent of all reported farm-related fatalities over the past three decades and presently account for approximately 1.1 percent of all farm-related fatalities; the 11 to 15-year-old age group had the highest frequency of cases; incidents occurred more often in the fall season; and augers, elevators, or conveyors were the type of implements most frequently involved. Recommendations to

enhance intervention strategies for PTO-related safety and for future research were also included.

Kunkler, J.M. 2004. **Analysis of Unintentional Childhood Injuries and Fatalities within Old Order Anabaptist Communities and Comparison to the General and Farm Populations.** Master of Science.

Abstract: Preliminary studies suggest that childhood injuries and fatalities in Old Order settings may be an increasing problem thus posing the need for better understanding of the childhood injury and fatality situation. This study's purpose was to develop a baseline of Old Order childhood injury data for 2002, analyze it in reference to specific underlying factors, and compare injury sources and fatality rates among Old Order Anabaptist children to those of the farm and general populations. Using the Old Order Anabaptist Injury Database, 495 injuries were identified during 2002 among Old Order children under the age of 18. Of those, 217 were incurred through agriculture-related incidents. Other injury categories reporting a large percentage of injury cases were transportation, household, and recreation respectively. The primary source of injury to all children was falls and the most commonly reported nature of injury was bone fractures. The age of victim most commonly reported was 4, and peaks in injuries occurred around ages 3-4 and 14-15. Population-specific factors were involved in many of the incidents including: direct animal contact, hay hole falls, buggy crashes, and horse-drawn equipment run overs. Forty of the injuries were fatal; 14 of those being agriculture-related and 10 directly related to fire. Of the agriculture-related fatalities, 6 were caused by horse-drawn equipment run overs and the rest were attributed to a crush/pin, fall, being struck by an object, direct animal contact, or engulfment in feed/grain. The comparison of nonfatal Old Order childhood injury sources with both the general and farm-related populations showed some similarities across cultural lines. The comparison of childhood fatality rates showed the Old Order rate to be approximately 2.8 times that of the general population. In comparison with the childhood farm population fatality rate, the Old Order childhood fatality rate was nearly the same with only the primary sources of injury being different. Based upon the findings of this study, recommendations were extended for culturally sensitive intervention strategies to be used in Old Order communities by parents, employers, and children. The recommendations focus specifically on resources and actions for each group involved as well as possible topics for further research.

Metcalf, J.M. 2005. **Enhancing Utilization of Upper Limb Prosthetics and Assistive Technology by Farmers and Farm Workers.** Master of Science.

Abstract: Farming is currently and has been historically one of the most dangerous occupations in the United States. One of the more common injury types is upper limb amputations. It was estimated in this study that between 464 and 541 upper limb amputations occur annually in the farming population and that there are currently between 8,100 and 9,400 upper limb amputees in the farming population. The estimated acceptance rate of upper limb prosthesis is approximately 25% which suggests there are approximately 6,000 to 7,000 upper limb amputees who are either unable to utilize currently available prosthesis devices or have rejected

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their devices. An agricultural worksite assessment tool for farmers with upper limb amputations engaged in farming. The tool consisted of 85 questions that ranged from prosthesis device concerns to estimating the level of difficulty required to complete both work-related and daily living activities. A set of 15 single and multiple on-site observations were made at the farms of 15 participants in the study. In addition an expert panel consisting of 5 upper limb amputees was convened for the purpose of identifying which farm-related and independent living tasks were considered the most difficult for an upper limb amputee to perform with or without a prosthesis device. The most difficult barriers identified were related to manipulation of small objects and controls, two-handed tasks, temperature control within the device and socket and harness fit comfort. Findings were analyzed and recommendations were made for needed engineering modifications, more effective utilization of assistive technology and strategies for enhancing the rehabilitation process.

Beaver, R.L. 2005. **Assessing the Nature, Frequency, and Causation of Entrapments and Fatalities Associated with On-Farm Storage and Handling of Livestock Manure.** Master of Science.

Abstract: Research was conducted to compile data on the nature and estimated frequency of deaths and injuries related to on-farm manure handling and storage facilities and to gain a better understanding of causative factors. Data were gathered by reviewing cases from published government reports, prior litigation, national and local media and other resources.

No prior studies were identified that addressed the magnitude of manure handling or storage-related fatalities and injuries, nor their causative factors.

Seventy-seven (77) fatal cases were identified that occurred in the United States between 1975 and 2004. An additional 21 injury cases and 14 international fatality cases were documented during completion of this project. Data concerning key causative factors were gathered including: the type of facility involved (pit, lagoon, swine, dairy), the age of the decedent, the activity at the time of death, the occupation at the time of death, and the reported cause of death. The data represent the largest compilation of systematically gathered information on this problem that is known to exist.

The data showed that the victim characteristics and causative factors did not reflect previously reported patterns. Previous safety efforts have primarily focused on swine operations but findings showed that 54.5% (42) of the deaths occurred in dairy operations and 44% (34) in swine operations. The data raised serious concerns about underage access to hazardous areas of farm operations including confined spaces by showing that 27% (21) of the documented deaths occurred to persons 20 years of age or younger, with 21% (16) involving persons under the age of 16.

The largest portion 34% (26), of the deaths occurred to persons conducting repairs or maintenance activities on manure handling equipment. It was found that 22% (17) of those fatally injured had entered the facility to perform an attempted rescue of another person.

Recommendations resulting from this study included the need to develop a centralized reporting system for injuries, illnesses, and deaths associated with agricultural confined spaces. Information concerning safety regulations and safe work practices contained in the OSHA confined space standard should be made available to all farm operators who own or manage confined space waste handling facilities, and they should be encouraged to

implement them. Work place safety standards should include the placement of signage or warnings at the entrance to all potential confined spaces used for manure handling and storage. Efforts should be made to update and expand the relevant ASAE engineering standards and practices that apply to agricultural livestock facilities and manure handling and storage facilities. Special considerations should be given to designs that reduce the need for workers to access potentially hazardous confined spaces. Finally, the Agricultural Hazards Order restricting access to any agricultural confined space that creates an unusually high level of hazard for the teenage or youthful farm worker or family member should be fully enforced.

Racz, C.W. 2006. **Assessment of Current Strategies for Disseminating Assistive Technology Information to Farmers with Disabilities.** Master of Science.

Abstract: Since the introduction of the USDA-CSREES AgrAbility program through appropriations in the 1990 farm bill, a variety of methods have been utilized to disseminate information to farmers with disabilities related to farming and essentials for living. To date, no known research has been conducted to assess various dissemination strategies from the perspectives of either the farmers with disabilities needing the information or the education and rehabilitation professionals who work with them. Because of this lack of research, unfounded assumptions have been made and conclusions drawn concerning how best to deliver the needed information, and has contributed to the use of ineffective dissemination methods, thereby wasting time and valuable limited resources. This study reviewed various strategies being used for dissemination of information to farmers with (and without) disabilities related to farming, essentials for daily living, and other technical topics, in order to identify methods documented to be most effective. It conducted surveys in order to summarize the perspectives of the USDA-CSREES AgrAbility Project staff and farmers with disabilities, relating to dissemination of assistive technology information and related resources and explored the potential strengths and weaknesses of using the Internet for information dissemination to AgrAbility customers. Significant findings included: farmers most preferred receiving assistive technology information in "printed newsletters" (71%) and "printed publications" (72%); AgrAbility staff most preferred receiving "Internet-based publication access" (61%), "email" (60%), and "printed publications" (58%); many farmers (53%) perceived dissemination strategies were moving toward the Internet, and a large portion (38%) perceived that assistive technology information was generally more available than in the past; both farmers and AgrAbility staff tended to agree that farmers wanted to receive information in printed format; and findings suggested that neither age nor educational level were strong predictors of Internet use by farmers. Recommendations were made to AgrAbility Project staff with regard to what strategies for dissemination of assistive technology information and related resources would be most effective, including: implementing proper management strategies for all information resources; proper planning, creation, and maintenance of web content; and avoiding the use of resources for language translation.

Bullock, S.R. 2006. **Evaluating the Effectiveness of a Visually-Based Farm Tractor and Machinery Safety Curriculum Compared to a Text-Based Curriculum.** Doctor of Philosophy.

Abstract: The goal of this project was to develop and test the effectiveness of a visually based instructional curriculum for use in providing farm safety training to youth with lower

levels of literacy and reading comprehension skills. The research was based upon utilization of an alternative visually based version of the Gearing Up for Safety- Production Agriculture Safety Training for Youth Curriculum developed as part of this research. This format of the curriculum was developed to meet the certification training requirements of the Federal Agriculture Hazardous Occupations Order for those youth who are unprepared to successfully utilize a text based manual or computer program due to limited reading comprehension skills. Through utilization of existing visual language forms such as pictorials, photographs, signal words, color combinations, and universal symbols, it was determined that the essential components of the Gearing Up for Safety curriculum could be effectively communicated to this population with outcomes comparable to those achieved with the text based curriculum.

The original curriculum was developed utilizing 170 core competencies and core content identified by researchers at Purdue University in the Departments of Agricultural and Biological Engineering, Youth Development and Agricultural Education, and a panel of external content experts. The knowledge gains were documented through the use of a validated test administered to 334 youth in Indiana, Kentucky, and Tennessee. The test scores from the visually-based version of the curriculum were compared to findings from the text-based computer curriculum and the effectiveness was assessed.

Although there was a significant difference in mean knowledge gains between the visually-based and text-based curriculum it was determined after calculating the effect size, that the difference between the means of the two instructional methods was small, and that the null hypothesis could not be rejected. The average knowledge gain across both instructional methods was 17.5%. Analysis using PROC Mixed with upper and lower quartiles based upon pretest scores showed no statistical difference between the two teaching methodologies. Prior experience with farm tractors and machinery showed a marked positive effect on the participant's performance on the pretest.

It was concluded that the visually-based format of the curriculum provided a viable alternative or compliment to traditional and computer-based instructional methods to reach populations with lower literacy and reading comprehension skills.

M. Roberts, 2008. **Summary of Prior Grain Entrapment Rescue Strategies and Application Principles Associated with using a Grain Rescue Tube as a Grain Retaining Device.** Master of Science.

Abstract: Because entrapment in flowable agricultural material continues to be a relevant problem, there has been a growing interest in both preventative strategies and developing more effective first response or extrication techniques. It was concluded that there was a need to develop evidence-based rescue strategies especially with respect to the use of grain entrapment rescue tubes that were being introduced as a form of grain retaining system to protect the victim from further entrapment and to aid in extrication. There was also a need for a summary of rescue techniques currently being used in real word situations and to document the history of grain retaining walls (GRWs) and how they developed into grain entrapment rescue tubes (GERTs), the only rescue devices specific to grain entrapment.

Significant findings included: from 1964 – 2006 an average of 16 entrapments were documented per year; of the 196 cases where the rescue technique was known, fifty-six percent (56%) included cutting or punching holes in the side of the grain storage structure

and nineteen percent (19%) of the cases utilized the construction of a GRW to extricate the victim.

It was determined that as the moisture content of corn increased from 13.6% to 21.9% the amount of resistance against the LRS Grain Rescue Tube sheet insertion increased from 1368 Joules to 2169 Joules.

Inserting the tube around the victim without removing any grain from inside the tube increased the amount of vertical pull needed for extrication of the victim. In the scenario where the victim was entrapped to the waist and underarms, placing the tube around the mannequin increased vertical pull by 26% and 22% respectively.

Recommendations for further study included: determining the safest way to cut into a large bin or silo (i.e., >20,000 bushels) without causing substantial structural fatigue, quantify coefficients of friction of various grains at varying moisture contents on UHMW plastic, analyze the effects of pulling a human body out of grain during extrication, and determine the most effective means of training volunteer first responders, full-time first responders, and elevator personnel in grain entrapment rescue techniques.

S. Mathew, 2009. **An Assessment Process to Estimate the Secondary Injury Potential of Assistive Technology Adopted by Farmers with Disabilities.** Doctor of Philosophy.

Abstract: Farmers with disabilities frequently fabricate or modify devices and worksites - referred to collectively as assistive technology (AT) - in order to continue performing required tasks on their farms. In some cases these AT have been documented to cause secondary injury. Further, some farmers having disabilities are not able to fully benefit from traditional funding sources, such as vocational rehabilitation agencies, because such one-of-a-kind or personally fabricated technologies fall outside "*normally*" funded services whose primary concerns include the reliability of the AT and/or the potential liability issues if injuries occur. It is believed that an assessment process with the appropriate empirical support to indicate the potential for secondary injuries with a reasonable degree of reliability may decrease the frequency and severity of injuries as well as reduce barriers to achieving employment and independence. Also, the validated assessment process can be a resource to train rehabilitation professionals in identifying potential injury hazards on both commercially available and locally fabricated AT used in the farm workplace. Hence the research goal was 'to develop a strategy supported by empirical data to identify potential AT-related hazards and the potential for work-related secondary injuries for farmers who adopt personally or locally fabricated AT to compensate for disabling conditions, through a consistent assessment process'. On-site case studies of 19 farmers with disabilities who fabricated AT for personal use were completed, and potential causative factors for secondary injuries were identified. A survey of 43 rehabilitation professionals, experienced in working with farmers having disabilities, was conducted to identify their perception of the significance of injury causative factors identified from the case studies. Relevant ASABE and SAE standards, OSHA workplace safety regulations and current agricultural workplace safe work practices were referenced to assess compliance with applicable safety standards and as a source of the state-of-the-art design practices. A prototype of the assessment process was developed and the same was validated using an expert panel consisting of six rehabilitation professionals

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evaluating nine different ATs. The desired outcomes included steps to (a) minimize secondary injuries caused by ATs, (b) help farmers with disabilities obtain funding for the purchase or fabrication of ATs, and (c) train rehabilitation professionals who work with farmers to identify potential disability-related hazards. Dissemination of the assessment process has been started with presentations to AgrAbility professionals involved in rehabilitation of farmers with disabilities, and also presentations at workshops and conferences.

A Mann, 2010. **Identification, Development, Validation, and Dissemination of Written Exam Items for the Agricultural Hazardous Occupations Order (AgHOs) Certification Training Program.** Master of Science.

Abstract: Research has been conducted to develop and validate a pool of exam items that can be used to test the readiness of youth, ages 14-15 years old, to be certified under the current federally mandated Agricultural Hazardous Occupations Order (AgHOs) contained within Title 29, Part 570, Subpart E-1 of the Code of Federal Regulations. Training is required prior to employment in agricultural workplaces that Congress determined are especially hazardous for youth within the prescribed age range. Under the current provisions of the AgHOs certification process, participants are required to successfully pass a written exam covering safe work practices as partial satisfaction to receive certification of eligibility for employment to complete certain tasks. However, the regulations provide little guidance concerning the format of the exam, subject matter to be covered, degree of difficulty, or minimum passing score. As part of the United States Department of Agriculture (USDA) sponsored Hazardous Occupations Safety Training in Agriculture (HOSTA) initiative, efforts have been made to develop consistent and evidence-based testing strategies and methods for disseminating the test protocols to instructors. The goal was to expand, enhance, and maintain the reliability of the item pool for the AgHOs certification process.

Item development was based on the HOSTA supported Gearing Up for Safety – Production Agriculture Safety Training for Youth (Gearing Up) curriculum. It was determined that the current item pool should be expanded to include a minimum of two test items for each of the 157 cognitive based desired core competencies that were developed as part of the Gearing Up curriculum design process.

Resulting from this research project to expand and maintain a pool of exam items were six major accomplishments:

1) Twelve item writing guidelines were identified for establishing AgHOs exam items,
2) One hundred seventy-four (174) preexisting items that met the learning outcomes of the Gearing Up curriculum were identified using the twelve guidelines,
3) One hundred-forty (140) new items were developed,
4) Validity evidence was collected to support the use of the 314 identified and newly developed items in the pool through an (a) item-competency alignment process using Subject Matter Experts (SMEs) and (b) empirical item analysis in which 16 instructors administered a 70 item exam generated from the pool of 314 items to 568 students across the U.S.,
   The pool of 314 evidence-based items and 53 previously validated items were made available to instructors of AgHOs certification training programs, and

5) Guidelines for item pool maintenance were proposed concluding this project.

W. Hoover, 2010. **Evaluating the Pre-Operational and Operational Test Instruments and Testing Strategies for the Gearing Up for Safety: Production Agricultural Safety Training for Youth.** Doctor of Philosophy.

Abstract: Current youth training and certification efforts, under the Agriculture Hazardous Occupations Order (AgHOs) regulations set forth by the Fair Labor Standards Act (FLSA), have not been standardized and in some cases have been determined to not meet even basic requirements of the order. This is especially true for hands-on evaluation components of the training intended to evaluate operator readiness to safely operate agricultural tractors and equipment. Variability in training and certification methods potentially leaves some youth, who are unprepared, at risk when encountering hazards while employed to operate allowable agricultural equipment.

The goal of this project was to evaluate Purdue University's Gearing Up for Safety: Production Agriculture Safety Training for Youth (Gearing Up for Safety) curriculum's assessment components designed to test tractor pre-operational and operational abilities of youth. Through a content validity study, the Pre-Operational and Operational Exams were determined to be reliable by a group of subject matter experts. Passing scores were also refined and finalized for each exam instrument: 70% for the Written Exam, 85% for the Pre-Operational Exam, and less than 15 infractions for the Operational Exam. Completion and critical evaluation of the Pre-Operational and Operational testing components complemented the previously validated Written Examination.

In addition to gathering validity evidence, the Pre-Operational and Operational Exams were determined, through very high correlations of the data, to provide consistent results with multiple examiners. Instructional resources were also created to assist program leaders when administering the Pre-Operational and Operational Exams.

The result of administering the Written Exam utilizing a pre-test/post-test method showed that there was a knowledge gain of 18.6% (13 questions). While there was an average increase of 18.5% in the mean score, the percentage of participants passing increased from 5.9% to 57.6%. Of those participants passing the Written Exam and completing the Pre-Operational Exam, a total of 38.5% passed. A total of 98.7% completing the Operational Exam passed, which indicated those participants lacking required knowledge and skills had been identified and removed during one of the first two stages of testing. The data further showed that 17.5% of participants successfully completed all three stages of testing. These findings suggest that the overwhelming majority of youth enrolled in the current AgHOs certification process lack the knowledge or skills to be employed in agricultural production occupations.

S. Riedel, 2011. **Estimation of the Frequency, Severity and Primary Causative Factors Associated With Injuries and Fatalities Involving Confined Spaces in Agriculture.** Master of Science.

Abstract: Research was conducted to assemble data on the estimated frequency, severity and primary causative factors associated with injuries and fatalities involving confined spaces in agriculture. Data were collected by reviewing cases from previously conducted research, local and national media (both on-line content and print sources), and published reports.

Based on a review of literature, no prior studies were found that either addressed the overall frequency, severity and causative factors of agricultural confined spaces or defined what clearly constituted an agricultural confined space. Studies on specific types of confined space incidents were identified, including those involving grain storage, manure storage, and grain transport vehicles.

A total of 1255 cases were identified in the United States between 1964 and 2010 fitting the definition of an agricultural confined space, as defined by the Committee on Agricultural Safety and Health Research and Extension for the North Central Region (NCERA-197). Data were collected on factors related to these agricultural confined spaces, to include the following: type and classification of facility (i.e. commercial grain storage, OSHA-exempt dairy manure storage, etc.), agent of injury (i.e. grain bin, above-ground manure tank, feed storage tank, etc.), age and gender of victim(s), geographic location of incident, and severity of incident.

Grain storage facilities accounted for 71.0% of cases, manure storage structures accounted for 10.5% of cases, agricultural transport vehicles accounted for 9.2% of cases, forage storage structures accounted for 5.7% of cases, and all other cases accounted for 3.6%.

Grain storage & handling facilities and grain transport vehicles collectively accounted for 80% of all cases. Of these 1004 cases, 795 (79.2%) involved entrapment or engulfment in a flowing agricultural material. Of these 795 entrapment or engulfment cases, 543 (68.3%) involved metal storage bins.

Males accounted for over 96% of all confined spaces-related cases and over 65% of all cases resulted in a fatality. Where age was known, the average age of a victim was 38 years, and youth under the age of 16 accounted for nearly 20% of cases.

The data were limited by the lack of reporting requirements, especially for non-fatal cases, and in many instances, lack of comprehensive epidemiological information.

R. Stuthridge, 2012. **The Consideration of Usability in the Process of Designing and Selecting Assistive Technology for Use in Agricultural Settings**. Doctor of Philosophy.

Abstract: Farming and ranching are hazardous, often arduous, occupations undertaken by a demographically varied population which suffers a higher than average prevalence of permanently disabling conditions. More than seventy percent of people with disabilities who work in agriculture choose to modify their tasks and work environment using "assistive technology" (AT) to enable them to continue working in this sector. AT is usually designed to meet the functional capacity only of its intended user (the "primary user"). In agriculture, however, AT may also be used by co-workers ("secondary users") It is not known whether AT used by secondary users is optimally designed to be usable by these people. A failure by AT designers to consider whether AT is usable by all users may inadvertently increase risk of injury for users for whom it is sub-optimally designed.

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This study investigated the process by which AT is designed for use in agricultural settings. Through the collection, analysis and coding of data generated from observations of AT design meetings, from interviews with designers of agricultural AT, and from design

resources cited by designers, a grounded theory of "the consideration of usability in the process of designing AT for use in agricultural settings" emerged.

The theory states that certain factors, both intrinsic and extrinsic to designers and users of agricultural AT, influence the consideration given during the design process to the utility and usability of AT. In particular, the influence of these factors results in a dichotomous imbalance between utility and usability, with utility having priority, while usability may be neglected. The task-orientedness of agricultural users of AT is an important factor in this phenomenon, inclining designers and users of AT to judge its success by its utility, rather than by its usability. The potential for designing usable AT is also undermined by the adoption of an exclusive, "ergonomics-for-one" design paradigm, which focuses strongly on meeting the needs of the primary user, while neglecting the potentially adverse effect that a modified task might have on other, "secondary users."

The need to raise awareness of usability during the design process led to the development of an "Agricultural AT Design Process (Usability) Checklist." The checklist was subjected to heuristic evaluation and field testing, and is presented in this dissertation. The study's methodological challenges, its implications for the AT design process, its potential applications, and areas for further research are also discussed.

P.S. O'Conner, 2012. **The Economic Impact of Extending OSHA's Grain Handling Standards to Currently Exempt Agricultural Worksites.** Master of Science.

Abstract: Historically, approximately 70% of grain-related incidents occur on farms, with the other 30% occurring at commercial facilities. However, most farms that have on-site storage structures are currently exempt from OSHA compliance as a result of OSHA's Agricultural Exemption. This research project attempted to estimate the cost of compliance of a convenient sample of seven representative currently exempt on-farm grain storage facilities with selected OSHA workplace safety and health standards requirements that were deemed most applicable to such grain handling facilities. An assessment tool was developed to gather information on those requirements that were judged as being reasonable for currently exempt on-farm grain storage facilities, and on-site visits were conducted. The level of compliance with the standards requirements was assessed at each on-site storage facility and found to be low. The cost analysis showed that a legislative change of this magnitude, assuming, for instance, an estimated per-farm implementation expenditure of $8,476, would result in a total first-year cost to the nation's 309,000-plus farms with on-farm grain storage of over $2.6 billion (not including the cost of bin retrofit to include adequate anchorage points). The cost of $8,476 includes labor costs of $4,200 and equipment costs of $4,276. Consequently, the findings presented support the belief that the economic impact of compliance would be significant.

S. Snyder, 2014. **Development of an Instructor Curriculum Model for the AgHOs Certification Program.**

Abstract: The USDA/NIFA has awarded funding to land Grant institutions to conduct and enhance the Hazardous Occupations Safety Training in Agriculture (HOSTA) program. The HOSTA program is designed to provide relevant educational opportunities in an effort to reduce the frequency and severity of farm-related injuries to all youth who work in agricultural production and to meet the current training requirements of the Agricultural Hazards Occupations Order (AgHOs) for non-exempt youth. The Cooperative Extension

Service and secondary school agricultural science and business programs are designated by the AgHOs as the only entities eligible to conduct and affirm completion of certification training. However, the law does not identify the minimum core competencies necessary for instructors and there are currently no evidence-based criteria to assess the preparedness of individuals who provide instruction to youth seeking AgHOs certification. One of the objectives of the current HOSTA project at Purdue University is to identify and validate prescribed criteria and desired core competencies for instructors who conduct certification training. This paper summarizes the findings of the validation process and reports on the core criteria and competencies identified.

S. Issa, 2015. **Evaluating the Impact of Forces on a Human Body While Being Rescued and Entrapped in Grain.**

Abstract: Grain entrapments and engulfments are one of most common hazards associated with grain storage facilities. Since the 1970's over 1,880 incidents have been documented in agricultural confined spaces of which 65% of all recorded incidents were grain entrapments and engulfments. There have been several studies conducted on the contributing factors behind these incidents; however, there have been very few attempts to understand the environmental, physiological or psychological factors the victims experience while entrapped, engulfed, or extricated. This includes understanding how secondary injuries are caused by grain or during extrication by first responders. The research effort was divided into three segments. The first segment is a literature review to identify and better understand the environmental, physiological and psychological stresses that an individual might be exposed to during grain entrapment, engulfment or extrication. The second segment expands upon previous studies that involved vertical pull tests (Schwab, Ross, Piercy, McKenzie, & B.A, 1985; Roberts, Field, Maier, & Stroshine, 2015) by testing forceful extrication attempts under a wider set of variables, including different types of grains (corn, popcorn, wheat, oats, soybeans, canola seeds and sunflower seeds), depths of entrapment, pull angles (15o, 30o, 45o, 60o, and 75o), limb placement and grain moisture content (corn only). With the exception of the pull angle test, these experiments were conducted only in a small scale setting. Pull angle tests were conducted in a full scale setting using a full sized mannequin (185 lb) in corn and soybeans. This is an important study since grain bin roofs are not generally designed for 5,000 lb anchor points. In addition, the tensile force limits of a sheep spine were tested and compared to the force needed to extricate a mannequin. The third segment focused on measuring the actual pressure that a victim might experience by pushing wooden plates against grain (simulating a rib cage pushing against the grain) and measuring the force. These experiments also focused on localized forces on the spine and limbs and estimating forces generated when a test mannequin is extricated at different angles. The literature review provided a total of eleven factors that negatively impact a victim's ability to survive a grain entrapment. The most important factor was asphyxiation (which includes aspiration, crush asphyxiation and postural asphyxiation). In 33 cases where the cause of death was medically reported, 63% cited asphyxiation. Another factor of notable

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importance is psychological, where it was found that stress could cause shortness of breath and chest pain and thus could be a contributing factor in death. In the extrication segment of the research, it was found that high moisture content could increase extrication forces by 39%. In addition, while shallow angles of pull did not significantly impact extrication force, pulling a victim at angles sharper than 45o degrees increased extrication forces by 22-44%. Lastly, the author found that the maximum tensile force that a spine can handle (1.65-2.48 kN) was in the same range of forces required to extricate a victim from between waist and shoulder depth. In the third segment of research, the author found that passive pressure on the victim was about four times larger than active pressure, thus a victim will experience four times more pressure in grain (while attempting to breath) than what a load cell measures. In conclusion, the best strategy to prevent or reduce the severity of injuries associated with grain entrapments remains prevention through compliance with accepted best workplace practice current workplace safety regulations. It was determined that 94% of all grain and engulfment incidents were preventable. Regarding methods of victim extr from grain entrapment it was concluded that there is a real and possible risk of secondary injuries, including spinal injury, if force is used to pull the victim from the grain. Reducing the pressure on the victim by removing the grain from around the victim is strongly recommended unless there are other significant medical issues that might reduce the likelihood of survival if extrication is not expedited.

C. Cheng, 2017. **Measuring The Effectiveness Of Delivery Strategies Used To Conduct An Evidence-Based Grain Storage And Handling Safety Curriculum Targeted Towards Young And Beginning Workers.**

Abstract: This research will involve the development, testing, and implementation of an original, evidence-based curriculum that is designed to reduce the most frequent types of injuries and fatalities that involve young and beginning workers at grain storage and handling operations. The curriculum being assessed will target workers specifically between the age of 14 to 20, which account for approximately one-fifth of documented entrapments, engulfments, asphyxiations, entanglements, falls, and electrocutions associated with grain handling and storage (Riedel & Field, 2013; Field, 2104). Curriculum contents will be based upon data currently documented in Purdue's Agricultural Confined Spaces Incident Database (PACSID), review of relevant research, and the provisions of applicable federal workplace safety and health standards. It will be developed using a standard curriculum development model and tested using sound educational measurement methods including pre- and post-testing, instructor evaluation and participant follow-up assessments. The three curriculum delivery techniques that will be assessed in the study are face to face secondary classroom instruction, face to face instruction in informal, out of school or workplace setting, and webinar-based instruction. An independent online instruction option will be explored, but not assessed. The economic viability or sustainability of each delivery strategy will also be assessed. Findings will be used to enhance the curriculum and made available to agricultural educators, and health and safety professionals in the grain industry, agricultural/farm organizations, and employer organizations.

S. Ehlers 2017. **Rearward Visibility Issues Related to Agricultural Machinery: Contributing Factors, Potential Solutions**.

Abstract: As the size, complexity, and speed of tractors and other agricultural self-propelled machinery have increased, so have the visibility-related issues, placing significant importance on the visual skills, alertness, and reactive abilities of the operator. Rearward movement of large agricultural equipment has been identified in the literature as causing not only damage to both machine and stationary objects, but also injuries (even fatalities) to bystanders not visible to the operator. Fortunately, monitoring assistance, while not a new concept, has advanced significantly, offering operators today more options for increasing awareness of the area surrounding their machines. In this research, an attempt is made to (1) identify and describe the key contributors to agricultural machinery visibility issues (both operator and machine-related), and (2) enumerate and evaluate the potential solutions and technologies that address these issues via modifications of ISO, SAE, and DOT standardized visibility testing methods. Enhanced operator safety and efficiency should result from a better understanding of the visibility problems (especially with regard to rearward movement) inherent in large tractors and self-propelled agricultural machinery.
Used in this study were nine machines of different types that varied widely in size, horsepower rating, and operator station configuration to provide a broad representation of what is found on many U.S. farms/ranches. The two main rearward monitoring 'technologies' evaluated were the machines' factory-equipped mirrors and cameras that the researchers affixed to these machines. A 58.06 m2 (625 ft2) testing grid was centered on the rear-most location of the tested machinery with height indicators centered in each of twenty-five grid cells. In general, the findings were consistent across all the machines tested—i.e., rather obstructed rearward visibility using mirrors alone versus considerably less obstructed rearward visibility with the addition of cameras. For example, having exterior extended-arm and interior mirrors only, a MFWD tractor with 1,100-bushel grain cart in tow measured, from the operator's perspective, 68% obstructed view of the grid's kneeling-worker-height markers and 100% throughout the midline of rearward travel; but when equipped with a rearview camera system, the obstructed area was decreased to only 4%. The visibility models created identified (1) a moderate-positive Pearson r correlation, indicating that many of the obstructed locations of the rearward area affected both mirrors and cameras similarly and (2) a strong-positive Pearson r correlation of kneeling worker height visibility, indicating that mirrors and camera systems share commonality of areas with high visibility (along the midline of travel and outward with greater distance from the rear of the machine, without implements in tow).

Of the recommendations coming from this research, the key one is for establishment of engineering standards aimed at (1) enhancing operator ability to identify those locations around agricultural machinery that are obstructed from view, (2) reducing the risk of run-overs through improved monitoring capabilities of machine surroundings and components, and (3) alerting operators and co-workers of these hazardous locations.

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