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[Session: Food Processing, Decontamination, and Disposal]

Carcass Disposal Options: A Multidisciplinary Perspective

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Thank you; I really appreciate the opportunity to be here to speak with you today. I'm going to talk today about the outcomes from the Carcass Disposal Working Group project, and I'll also briefly highlight the interdisciplinary team approach that was used. I want to point out that I'm here representing a very large team of people who worked on this project; other key team members in terms of coordination were Dr. Justin Kastner, Jackie McClasky, and Dr. Curtis Kastner at K-State. I'll say more momentarily about the other people and institutions that were involved.

Just a few comments to start as to "why bother," why bother crossing disciplinary frontiers; why try to work across disciplines? I think the answers are probably obvious, but just to illustrate I have a quick example. If I provide you this piece of information, [thenewyorktimes.com](#) (page unavailable), it may perhaps give you some ideas about the event to which I'm referring. However, that single piece of information by itself isn't terribly useful. If I also provide a date, that may help. That's one more piece of information, one more perspective, but that still may not give you the whole story. Another clue helps. Some of you may be nodding; you may have figured out what I'm referring to. The point is that the more perspectives you have the more accurate the picture you can paint.

Academics – what is an academic discipline anyway? One definition might be "making sense of the world within a particular community or tradition of reason". Within disciplines we have conventions of speech, we have lingo, we have certain assumptions, and those very things often prevent us from painting an accurate illustration of a problem, or the solutions to a problem. No doubt this morning I'm preaching to the choir, but there is value in blending insights from different disciplines. Obviously the planning committee for this meeting subscribes to this philosophy as well; the program clearly includes experts with a variety of different perspectives to talk about food protection and defense. Blending disciplinary insights was the goal of the carcass disposal project team. The primary outcome of that project is a comprehensive carcass disposal report. The report is available on-line; hopefully you can see the website address there at the bottom. I'll present that again later, and I understand these slide materials will also be available to you so that you can access that if you would like.

This project was essentially a cooperative agreement project for the USDA Animal and Plant Health Inspection Service (APHIS) and it involved a variety of institutions, Kansas State being one, Purdue Univ., Texas A&M, as well as other entities. The objectives were to summarize the available information about the disposal options that may be used to deal with a large-scale carcass disposal event. An additional

objective was to frame some of the other issues—the logistical issues, the social science issues—that go along with such events regardless of the type of disposal option that might be used.

The previous speaker provided an excellent overview of the enormity of animal agriculture in the U.S. Regardless of the cause behind a large scale carcass disposal event – an outbreak of disease or an act of weather – planning and preparation are essential. Wide-spread livestock deaths pose daunting disposal challenges—that's evident from past incidents both here in the U.S. and worldwide. Events must be addressed quickly in order to minimize economic problems, environmental consequences, and many other issues. The vulnerability of animal agriculture is accentuated by 2 things—an increasing concentration of modern animal production, and the mobility of food animal populations. These same 2 attributes (increasing concentration and mobility) are true of the food supply in general. Although I'm talking here today specifically about disposal of carcass, these same disposal options could be applied to almost any kind of waste—food waste, and so on. In a sense, carcasses are just one particular type of waste.

Our first objective was to identify and summarize the available information—what do we know about different carcass disposal options? Unfortunately, the U.K. has dealt with several animal disease events in the recent past – namely BSE and, even more recently, FMD. It would do us well to learn from their experiences, and perhaps avoid some of the problems they faced. For example, this is a decision tree that was used by the U.K. Dept. of Health during the FMD outbreak. At the outset of this carcass disposal project, we considered developing a similar decision tree that could work for us here in the U.S. The problem is that it doesn't necessarily account for the many complicating factors that emerge. That is, what may be good for disposing of beef carcasses in Kansas as a result of FMD may not be appropriate for disposing of poultry in California as a result of Newcastle, or hogs in North Carolina following a hurricane.

Prescriptive hierarchies—though they are probably helpful in some cases—can be of limited usefulness from an overall perspective. So rather than set about developing a prescriptive hierarchy or a decision tree, we decided instead to focus on creating a resource for those at the local or county or state level who have to plan for disposing of animal carcasses – equip them with information about what is available, what options they might have. We wanted not only to arm them with a comprehensive understanding of the disposal technologies that are available, but also to provide information about those cross-cutting issues that we talked about.

I mentioned that this project team was very large; it consisted of approximately 30 people, not only from several institutions but from a host of backgrounds. As you can see from this list, the team included veterinarians, engineers, historians, economists, communication experts, people with expertise in GIS, as well as security experts. Though not specifically mentioned earlier, another partner institution was Sandia National Laboratories from the security side.

The outcomes from this project were threefold—a report, a conference, and a reference database. The report—and I'll show you some additional details in just a minute—is a comprehensive document that covers disposal technologies, chapter-by-chapter, and technology-by-technology. It also covers some of these cross-cutting issues. In conjunction with this project, in 2003 we hosted a regional Carcass Disposal conference in Kansas City, so Kansas and some of the surrounding states participated. It was an opportunity to bring together people from animal health agencies in those states, environmental agencies (like the Kansas Dept. of Health and Environment), and producers—groups who might not normally come together—in a room to talk about carcass disposal and emergency preparedness issues. I should note that a transcript and handouts from that conference are available if anyone is interested. The third project outcome that I will only mention briefly is the reference database. As you can imagine, in compiling this report of over 700 pages we accumulated a large number of references and citations. Although those materials are captured in the report itself by way of bibliography, we are also trying to make them available in the form of a special collection within the K-State digital library so that the database is searchable for information on a particular subject.

Back to the project report, I'm going to go quickly through and give you some highlights from this report – the point is simply to give you the flavor of what is contained there. It's certainly not possible to go through it in detail, but it's available on the web if you would like more information. The report is split into two major sections. Part one deals with the actual disposal technologies themselves—the means we can use to dispose of carcasses. The second part deals with those cross-cutting issues that should be considered regardless of the technology chosen. Carcasses as waste – I mentioned that carcasses are essentially just another type of waste. However, they are a difficult-to-handle waste stream because of high water content. This is an example of the estimated volume of fluid released per carcass, obviously a key challenge. Relative to the means by which carcasses could be disposed, we looked at a whole series of characteristics for each disposal technology. We considered aspects such as expertise and personnel requirements, location considerations, time requirements (how long does it take using that particular technology), cost issues, disease agent considerations (does it work for BSE, FMD, avian influenza), environmental implications, monitoring requirements, and so on. Ultimately we tried to compile a list of advantages and disadvantages of the various technologies.

I'll go through some of the technologies we evaluated very, very briefly to give you a sense of what is contained in the report. As an example, for burial related options we summarized trench burial, landfill options, and engineered mass burial sites. Information about the latter option came primarily from the U.K. as a result of the FMD outbreak; again, it's important to learn lessons from those with experience.

Reiterating some of the things that we looked at for these different technologies, for burial an example would be the area required; that is, how much space do you need if you are going to dispose of cattle or hogs or sheep or poultry? We found lots of different estimates in the literature; those are cataloged in this report. In terms of resources and time – what equipment is required, how long will it take to dig a hole of X cubic feet or yards using a particular piece of equipment? Because carcasses have high-water content, there is liquid to deal with in terms of burial.

Here are examples of various composting technologies that were summarized in the report. Composting has become an increasingly preferred alternative, most notably for disposal in non-emergency situations such as disposal of routine mortalities from a production operation. One thing I'll note about the report in general—it is a snapshot in time. No doubt there have been technological advances that are not captured in the report because it was completed about a year ago.

Here are examples of various incineration technologies, burning – open burning, the photograph there depicts incineration as used in the U.K. for the FMD outbreak. The picture on the top left shows what's called “air curtain incineration,” which is a contained type of incineration. One disadvantage of incineration in general as a means of disposal is the supplemental fuel required to overcome the high-water content of carcasses.

Alkaline hydrolysis, or alkaline digestion, is another technology that is chronicled in the report from the standpoint of capacity, process time, and costs. This technology may be most familiar to you in the context of disposal of TSE-infected materials. Studies have shown this disposal method can effectively eliminate the agents of TSEs, such as BSE and CWD. This technology is a batch process and units of varying capacity are available. The report provides a range of cost estimates.

A sub-group of our research team evaluated what we referred to as “non-traditional” or “novel technologies,” some of which may seem a bit far-fetched or even humorous. Examples of these non-traditional technologies include “re-feeding,” that is, feeding carcasses to other species such as alligators; ocean-disposal; plasma arc processes; and thermal depolymerization. Some of these have been used experimentally for carcass disposal, others are theoretical possibilities. Generally the disadvantages of these include that they are of limited capacity, are costly, and/or are not commercially available.

Though that's only the tip of the iceberg, hopefully that brief synopsis gives you a sense of the report contents in terms of disposal technologies. Part two of the report addresses what we have called the cross-cutting dimensions—issues that are relevant regardless of the disposal technology used. I'm only going to talk about two in particular as examples, and I'll provide the website again so that you can access the report if you want more information on any of the others.

The first example is the use of GIS, geographic information systems, as a tool to identify potential burial sites. In Southwest Kansas there are several very large feed lots. The Kansas Animal Health Dept. (KAHD) has indicated that, in the event of a disease outbreak like FMD, burial is the preferred disposal option; it was selected largely to avoid spreading disease by transporting carcasses. That begs the question, “Where can carcasses be buried?” K-State geographers and GIS experts have worked with the Kansas Dept. of Health and Environment to develop a carcass disposal site selection model that helps pre-identify sites that are, or are not, acceptable for burial. To illustrate, this map shows Finney County, Kansas, which is home to several large feed lots. The shading on the map shows sites that have been classified as suitable, or not suitable, based on data layers such as population, soil type, depth to groundwater, and so on. I know other states have done similar planning work in terms of using GIS technology to pre-identify potential disposal sites.

The second cross-cutting issue example is that of costs and economic considerations. The purpose of this portion of the report was to summarize information that could speak to the magnitude of representative costs for various disposal technologies. Ideally we hoped to obtain estimates of disposal costs incurred during actual large-scale disposal events (disease outbreaks, natural disasters, and so on). We found that such cost estimates were relatively scarce in the literature. Instead cost information more frequently reflected that which could be expected for disposal of routine mortalities in a production operation.

One word of caution about comparing cost estimates between or across disposal technologies: we observed that estimates in the literature varied considerably in terms of what comprised the estimate. For example, some included capital costs, others did not; some included labor costs, others did not. The underlying assumptions or circumstances of cost estimates also varied. For example, some cost estimates were based on the disposal of poultry carcasses; this may or may not be relevant for disposal of beef cattle carcasses.

In short, cost estimates should be viewed with caution. The graph on this slide is somewhat busy and those of you in the back may not be able to read it clearly. The purpose of the graph is to depict the range of cost estimates that we identified for each disposal technology listed. As you can see, some technologies have a wide range indeed. Again that reflects the differing assumptions and/or inputs accounted for by the estimate. Cost is certainly not the only important factor to consider in planning for appropriate disposal methods. This report also addresses issues such as environmental consequences, equipment availability, and public perception – any or all of which may be critical. For example, in the aftermath of the U.K. FMD outbreak, officials indicated that

open burning—pyres—would not be used in the future. Though numerous studies and environmental monitoring indicated these pyres resulted in little or no environmental damage, the damage to public perception was tremendous and, therefore, this method would not be employed in the future.

In summary, a rapid response is key to mitigating an event requiring large-scale disposal of animal carcasses. The best means of preparation is to have a thorough understanding of all available disposal technologies and to employ any and all that are deemed appropriate. This report is intended to serve as a resource for those tasked with planning for these kinds of events, to provide information about what the disposal options might be. At the end of the day it will probably not be about finding the one best disposal technology, but instead will be about exploiting all disposal options that are available and suitable for the particular event at hand.

As promised, here again is the website where the report is posted and available for download. I have also provided at the end of this slide set a list of selected references that may be of interest. I'd be happy to take any questions that you might have.

Carcass Disposal Options

a multidisciplinary perspective

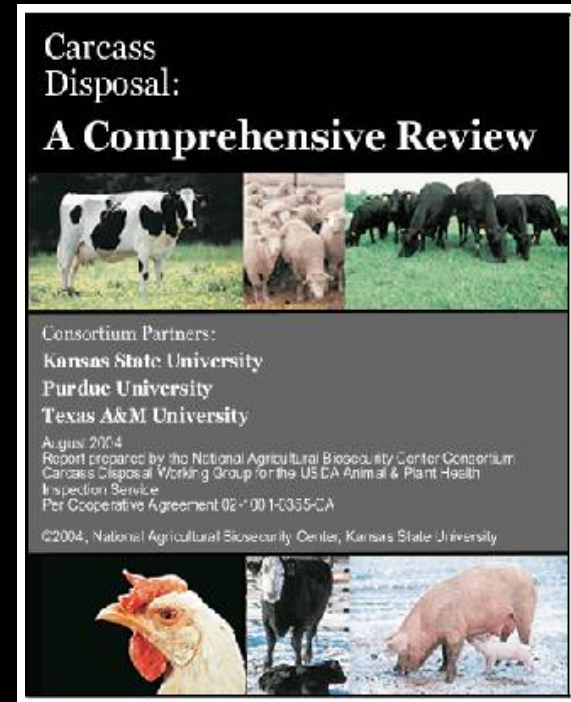


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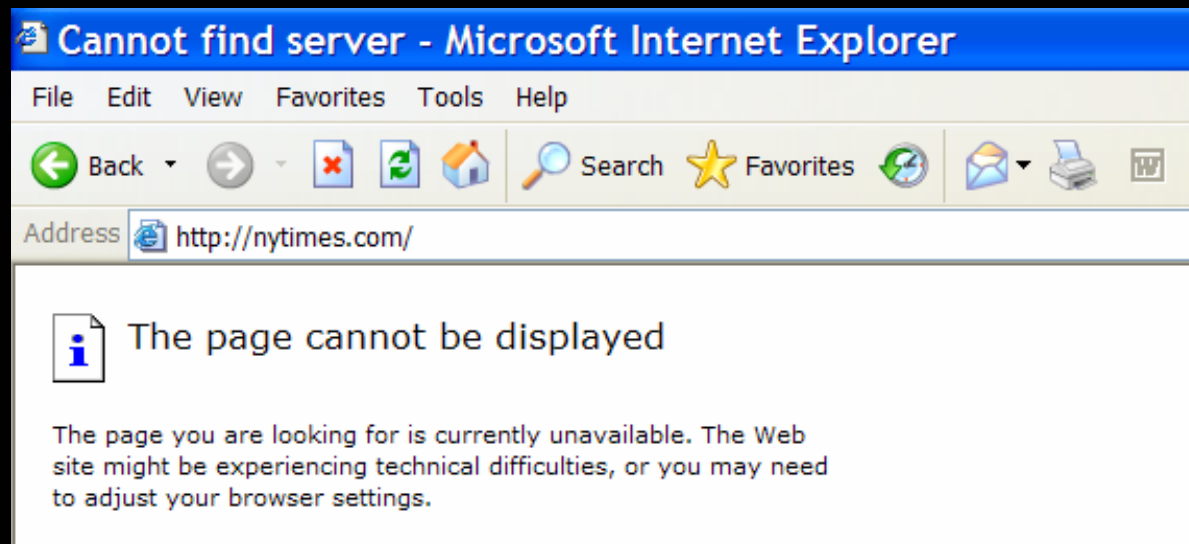
- Carcass disposal working group project
- Interdisciplinary team approach

- Key team members
 - Dr. Justin Kastner
 - Jackie McClaskey
 - Dr. Curtis Kastner, PI





Why cross disciplinary frontiers?

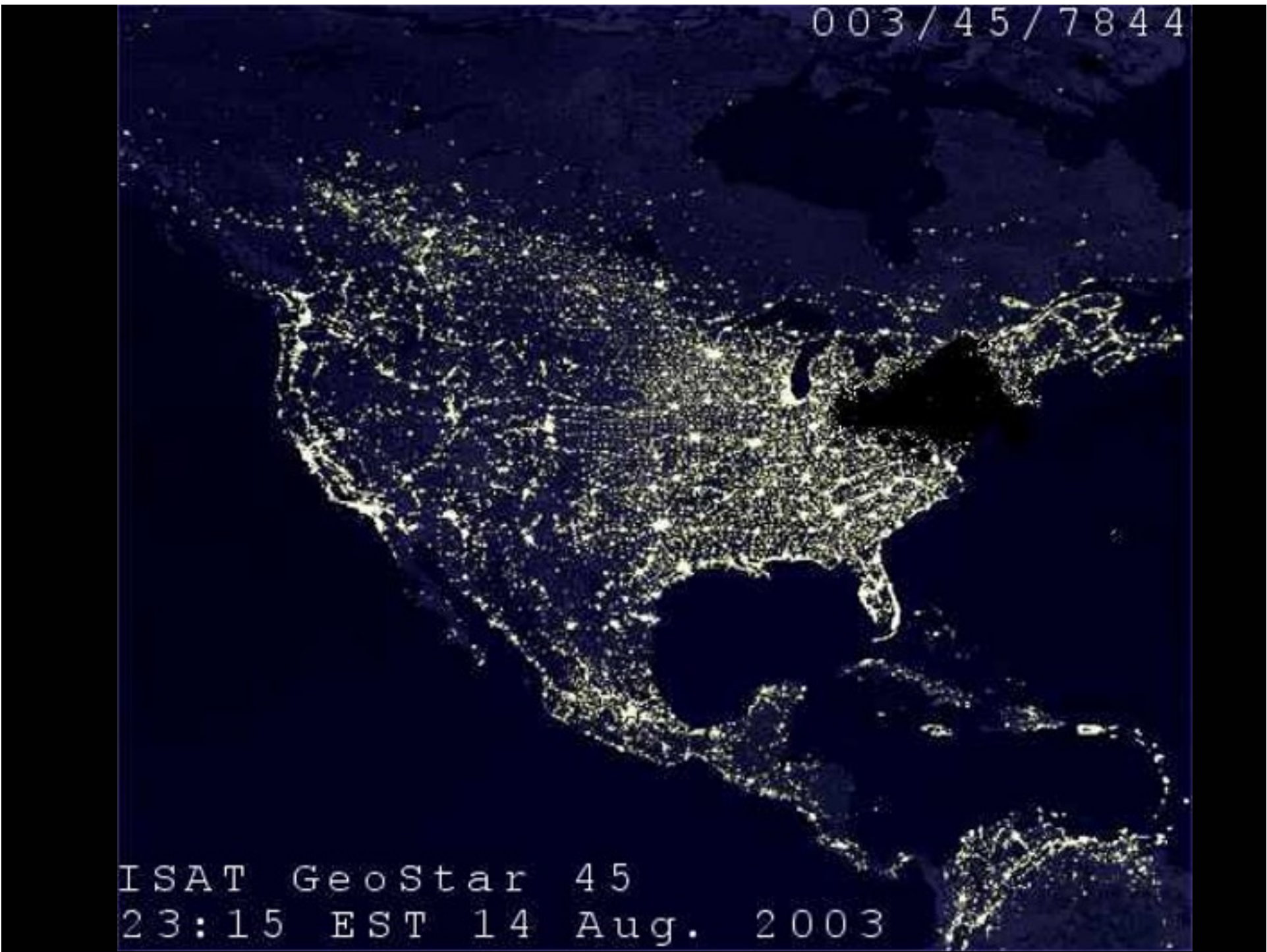


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Academic discipline...

...involves making sense of the world within a community & tradition of reason

- adhere to the community's "speech"
 - feature certain assumptions & practices
-

Single-discipline studies may fail to capture the multiple dimensions of food safety & security





By blending insights from multiple disciplines, scholars can paint truer pictures of today's food safety and security problems.

Commentary of 9 March 2005, "Food Safety & Security: more discipline(s) required," by C. Kastner, J. Sargeant, & J. Kastner (<http://fss.k-state.edu>)



Carcass Disposal: A Comprehensive Review

2002-2004

Carcass Disposal: A Comprehensive Review



Consortium Partners:
Kansas State University
Purdue University
Texas A&M University

August 2004
Report prepared by the National Agricultural Biosecurity Center Consortium
Carcass Disposal Working Group for the US CA Animal & Plant Health
Inspection Service
Per Cooperative Agreement 02-001-0355-CA

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Available online: <http://fss.k-state.edu/research/books/carcassdisp.html>



Food Safety & Security at K-State | <http://fss.k-state.edu> | a program of targeted excellence

USDA-APHIS Cooperative Agreement Project

- **Collaborators:**

- Kansas State University
- Purdue University
- Texas A&M University



- **Objectives:**

- summarize available information concerning existing disposal technologies
- frame cross-cutting logistical, social, and economic considerations of large-scale disposal
- identify knowledge gaps warranting research or educational efforts



Carcass disposal: problem statement



- Events may arise from accidental disease entry, the weather, or an act of bioterrorism
- Widespread livestock deaths pose daunting carcass-disposal challenges
- Must address quickly and effectively to minimize food security problems, economic losses, and environmental consequences

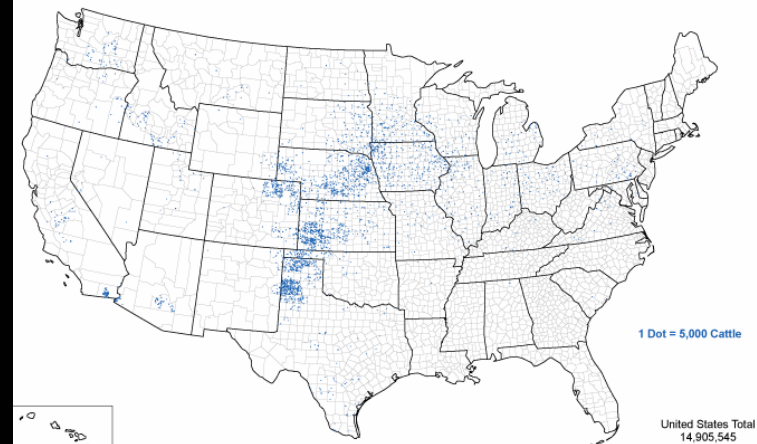


Vulnerability accentuated by

- ever-increasing **concentration** of modern animal production
- tremendous **mobility** of food-animal populations



2002 Cattle on Feed | 14,905,545

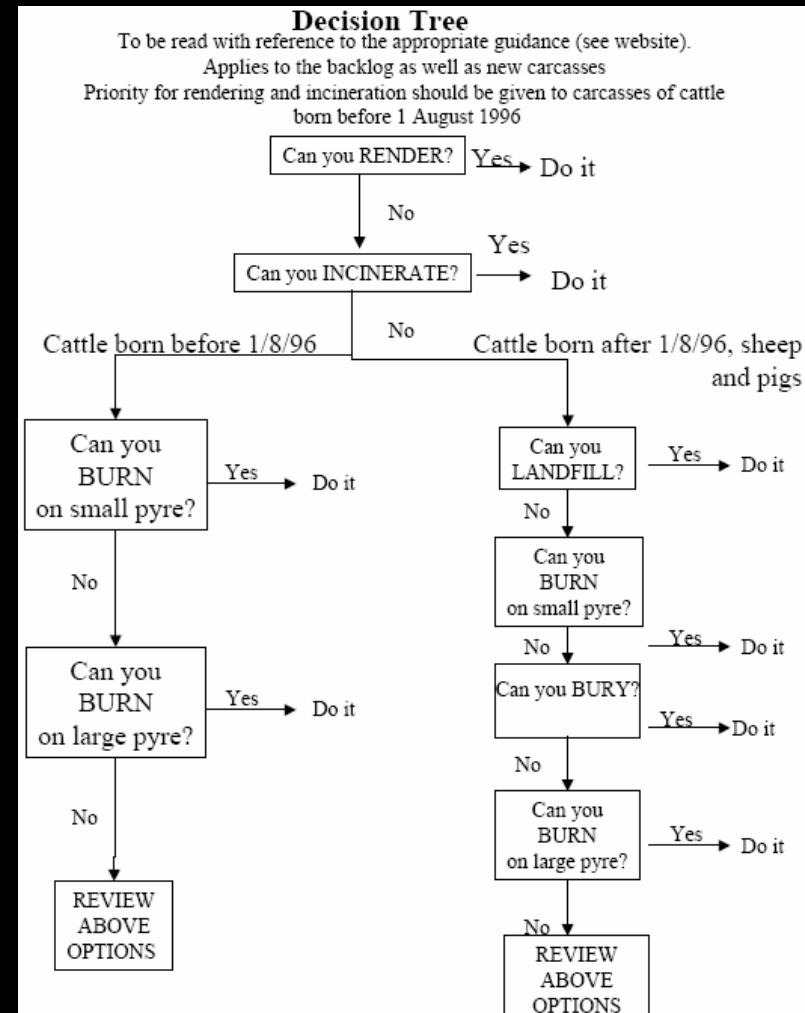


<http://www.nass.usda.gov/research/atlas02/atlas-livestock.html>



Promoting emergency preparedness

For a problem such as carcass disposal, it may be tempting to prescribe step-wise, disposal-option hierarchies outlining the most and least preferred disposal methods.



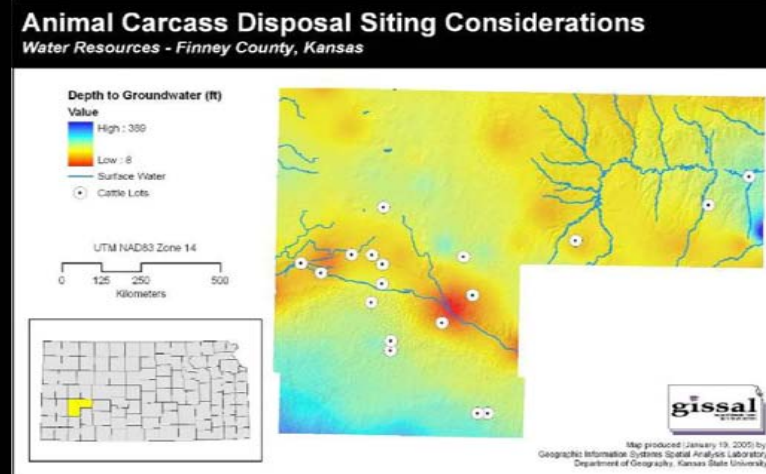
SOURCE: UK Department of Health. 2001. Foot and mouth disease - measures to minimise risk to public health from slaughter and disposal of animals - further guidance.
<http://www.dh.gov.uk/assetRoot/04/01/95/53/04019553.pdf>



Prescriptive hierarchies?

may be of limited value as they do not fully capture and systematize the relevant dimensions at stake

- environmental considerations
- disease agent considerations
- availability of the technology
- public perception
- etc.



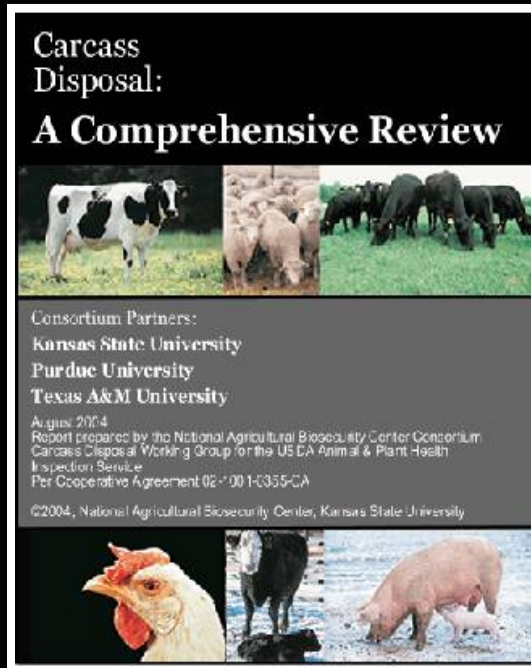
Multiple dimensions require multiple disciplines

In order to effectively plan and prepare, one must be armed with a **comprehensive understanding** of

- an array of carcass disposal technologies
- the accompanying “cross-cutting” issues



A truly multidisciplinary approach

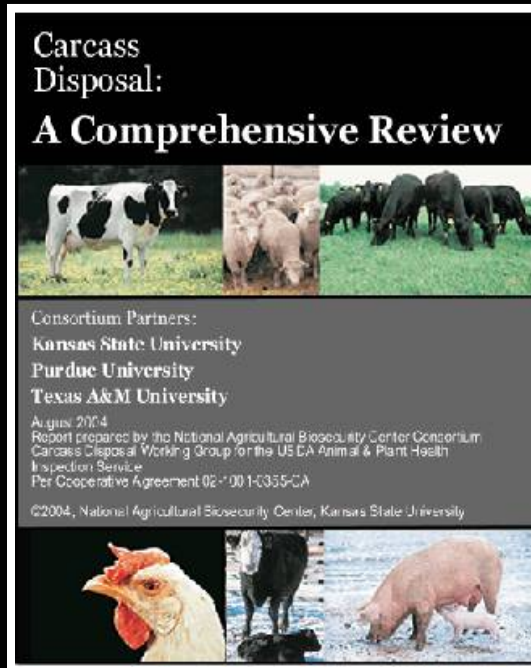


Team included:

- ❑ Biol. & Ag. Engineers
- ❑ Veterinarians
- ❑ Social Scientists
- ❑ GIS Scientists
- ❑ Historians
- ❑ Chem. Engineers
- ❑ Economists
- ❑ Security Experts
- ❑ Communications Experts
- ❑ Extension Specialists



A truly multidisciplinary approach



Outcomes...

- Report
 - 700+ pages, 17 chapters
 - Web-stats indicate 10,000+ downloads
- Regional Conference
 - Animal health, environment, public health, industry, academia
- Reference Database
 - 1,000+ citations
 - Will incorporate into KSU digital library



Carcass Disposal: A Comprehensive Review

Part 1 – Disposal Technologies

- Burial
- Incineration
- Composting
- Rendering
- Lactic Acid Fermentation
- Alkaline Hydrolysis
- Anaerobic Digestion
- Novel Technologies

Part 2 – Cross-Cutting & Policy Issues

- Economic & Cost Considerations
- Historical Documentation
- Regulatory Issues & Cooperation
- Public Relations Efforts
- Physical Security of Disposal Sites
- Evaluating Environmental Impacts
- GIS Technology
- Decontamination of Sites
- Transportation



Carcasses as waste

- Carcasses represent a difficult-to-handle waste stream due to high water content

Species	Est. volume of fluid released per animal, in L	
	First week postmortem	First 2 months postmortem
Cattle – Adult (500-600 kg; 1100-1300 lbs)	80	160
Cattle – Calf	10	20
Sheep – Adult (50 kg; 110 lbs)	7-8	14-16
Sheep – Lamb	1	2
Pig – Adult	6	12
Pig – Grower/finisher	3	6
Pig – Piglets	0.4	0.8

(adapted from Munro, 2001)

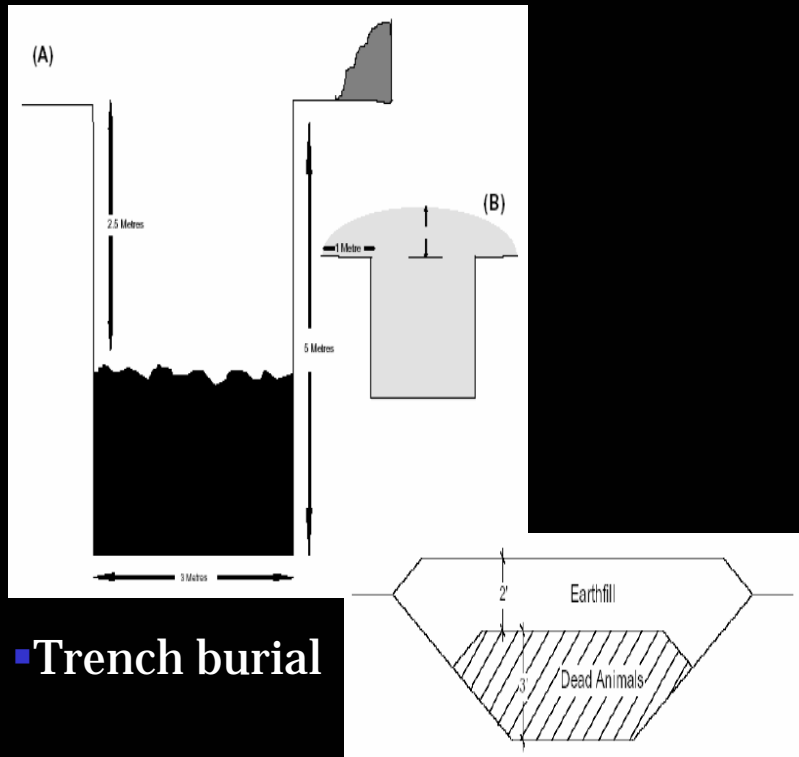


Part 1 – Disposal Technologies

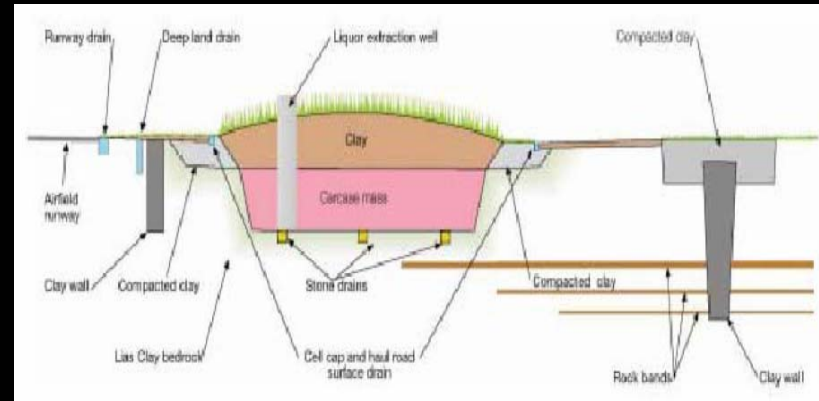
- Considered a multitude of issues for each disposal technology evaluated:
 - Expertise/personnel requirements
 - Location
 - Resource requirements
 - Time requirements
 - Clean-up/remediation
 - Cost/economic factors
 - Disease agents
 - Environmental implications
 - Monitoring requirements
 - Other factors
- Potential advantages & disadvantages of the various options



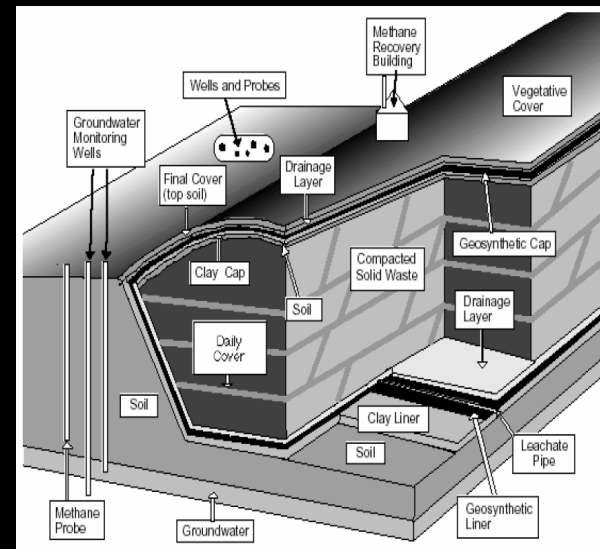
Burial related options



■ Trench burial



■ Engineered mass burial sites



■ Landfill



Burial

Area Required

- Estimates: 1.2 to 3.5 yd³ per mature cattle carcass
- Example - 30,000 head of mature cattle:
 - Assuming 3 yd³ per carcass & trench depth of 8.5 ft, required land surface = ~6.7 acres (~5 football fields)

Resources & Time

Carcass Units @ 1000 lbs ea	Approx. Excavation Volume Required ^a	Approx. Alternative Trench Dimensions (L x W x D)	Approximate Excavation Time (Hours)		
			13 yd scraper (78 cu yd/hr)	15 yd scraper (103.3 cu yd/hr)	27 yd scraper (162.03 cu yd/hr)
5,000	7,500 cu yd (202,500 cu ft)	450 ft. x 45 ft x 10 ft 250 ft x 81 ft x 10 ft	96.2	72.6	46.3
10,000	15,000 cu yd (405,000 cu ft)	450 ft x 90 ft x 10 ft 250 ft x 162 ft x 10 ft	192.3	145.2	92.6
25,000	37,500 cu yd (1,012,500 cu ft)	450 ft x 225ft x 10 ft 180 ft x 562 ft x 10 ft	480.8	363.1	231.5
50,000	75,000 cu yd (2,025,000 cu ft)	450 ft x 450 ft x 10 ft 180 ft x 1125 ft x 10 ft	961.5	726.2	462.9

^aAssume 1.5 yd³ of excavation area required per 1000 lb carcass unit.

Implications

Species	Est. volume of fluid released per animal, in L	
	First week postmortem	First 2 months postmortem
Cattle – Adult (500-600 kg; 1100-1300 lbs)	80	160
Cattle – Calf	10	20
Sheep – Adult (50 kg; 110 lbs)	7-8	14-16
Sheep – Lamb	1	2
Pig – Adult	6	12
Pig – Grower/finisher	3	6
Pig – Piglets	0.4	0.8



Composting

- Composting is becoming an increasingly preferred alternative for disposing of mortalities at animal feeding operations.
- Configurations include



■ Bin



■ Windrow



■ In-Vessel (e.g., Ag Bag)



Incineration / burning

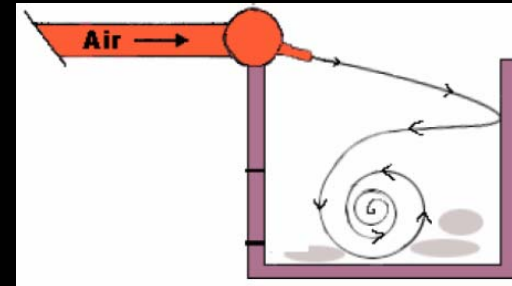


TABLE 2. Types and quantities of materials required for an open-air burn (McDonald, 2001; Smith et al., 2002, pp.24-26).

	Straw or hay	Untreated heavy timbers	Kindling wood	Coal	Liquid fuel (e.g., diesel fuel)
Per:	3 bales	3 timbers, each 8ft (~2.5m) by 1ft sq (~0.3m sq)	50 lbs. (~23 kg)	500 lbs. in large clumps, 6-8 inches (~15-20 cm) in diameter	1 gallon (~4L)
1 bovine carcass,					
5 swine carcasses,					
or 5 sheep carcasses					



Alkaline hydrolysis

Capacity, Process Time, & Costs

- Fixed-facility units up to 10,000 lb capacity
- Mobile units up to 4,000 lb capacity
- Process time 3-6 hours
- Cost estimates:
 - \$40 to \$60/ton (excluding capital and labor costs; Wilson, 2003)
 - \$320/ton (Powers, 2003)

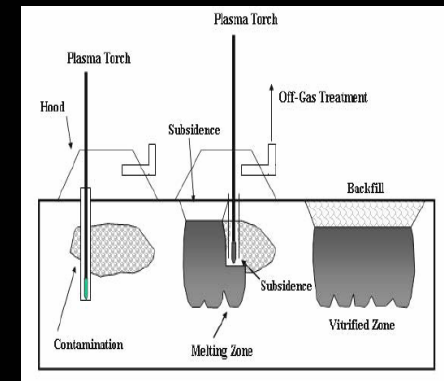
TABLE 3. Cost estimates for operation of an alkaline hydrolysis tissue digester with 2,000 lb capacity (Powers, 2003).

Item	Cost (\$ per lb of carcass material processed)
Steam, water, electricity	\$0.01/lb.
Chemicals (NaOH, KOH)	\$0.02/lb.
Personnel (4 hours/day for 2 cycles)	\$0.04/lb.
Sanitary sewer costs	\$0.07/lb.
Maintenance & repair	\$0.02/lb.
Total	\$0.16/lb.



Non-Traditional / Novel Technologies

- Lactic acid fermentation
 - Anaerobic digestion
 - Thermal depolymerization
 - Plasma arc process
 - Novel pyrolysis technology
 - Refeeding
 - Ocean disposal
 - Non-traditional rendering
- **Disadvantages of all generally include one or more of the following**
 - Limited capacity
 - Costly
 - Lack of commercial availability



(Circeo & Martin, 2001)



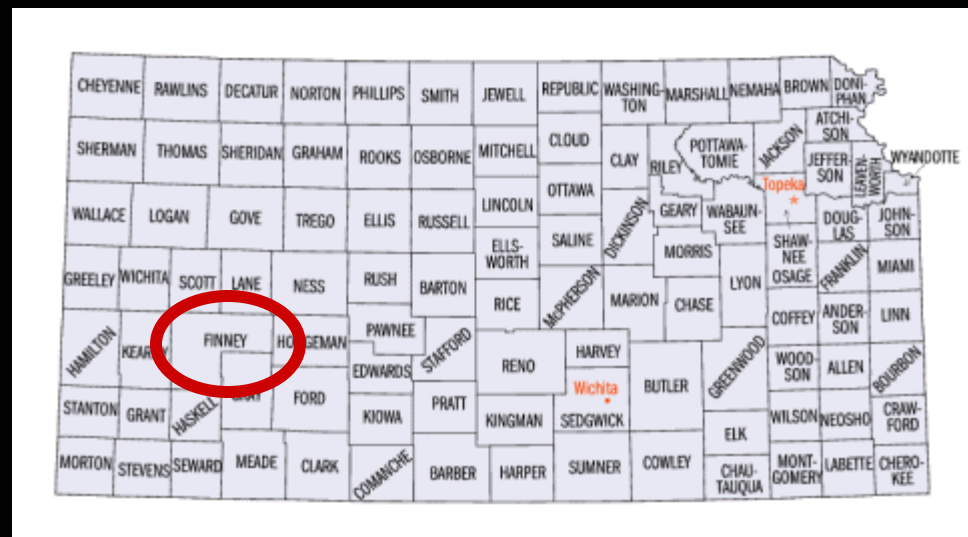
Part 2 – Cross-cutting dimensions

- Regulatory issues and cooperation
- Public relations
- Physical security of disposal sites
- Evaluating environmental impacts
- Geographic Information Systems (GIS) technology
- Decontamination of sites and carcasses
- Transportation
- Economic and cost considerations

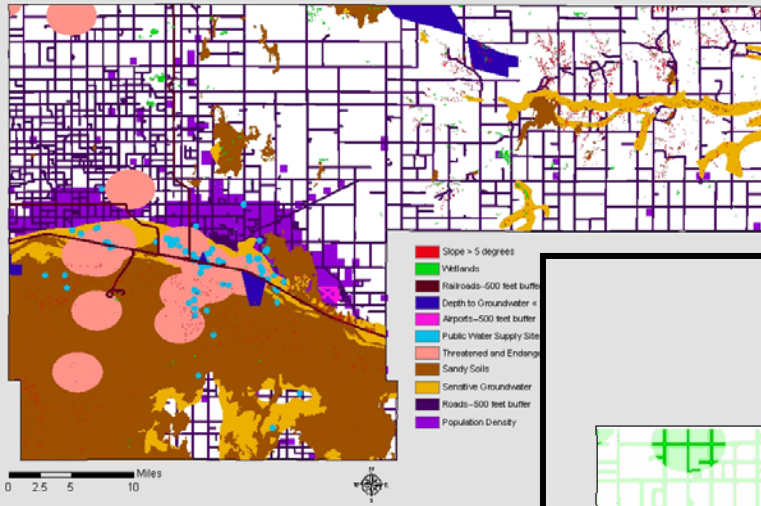


Geographic Information Systems

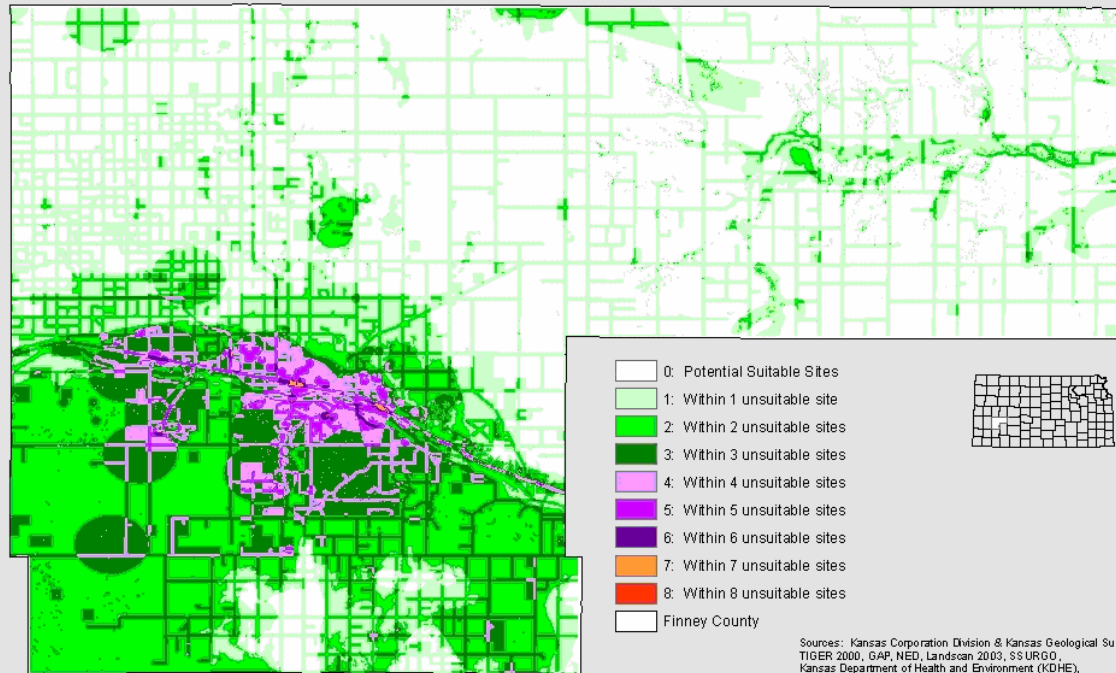
- **Example – Where can carcasses be buried?**
- K-State geographers and Kansas Department of Health & Environment have developed a carcass disposal site selection model



Food Safety and Security
 Unsuitable Sites for Livestock Carcass Disposal
 Finney County, Kansas



Food Safety and Security
 Unsuitable Sites for Livestock Carcass Disposal
 Finney County, Kansas



Sources: Kansas Corporation Division & Kansas Geological Survey
 TIGER 2000, GAP, NED, Landscan 2003, SS URGD,
 Kansas Department of Health and Environment (KDHE),
 Kansas Biological Survey, Kansas Department of Wildlife and Parks
 Created by Lori Emerson on June 7, 2005
 Geographic Information Systems Spatial Analysis Laboratory (GIS SAL)
 Department of Geography, Kansas State University
 Projection: Geographic NAD83
 Overview Projection: Lambert Conformal Conic, central meridian = -98.15

Economic Considerations

- Cost estimates available in the literature
 - few cost estimates exist for large-scale emergency disposal
 - generally reflect costs associated with routine disposal or limited emergency experiences
 - probably inadequate consideration of costs related to environmental impact, land values, public opinion, etc.
- **Cost comparisons among technologies should be considered with caution:**
 - 1) data from different sources are based on a variety of assumptions, including differing circumstances, cause of death, scale of disposal efforts, species, dates, and geographical locations, etc.
 - 2) reported cost estimates do not consistently incorporate capital, transportation, labor, or input costs



Economic & Cost Considerations

Technology	Range of cost estimates per ton of carcass material disposed ^a	Direct Cost Indicators				Indirect Cost Indicators			Creates valuable or beneficial by-products
		Initial Capital ^b	Transportation ^c	Labor	Inputs	Environment /Public Health	Public Perception	Other cost considerations	
Burial (on- and off-site)	\$15-200	\$	\$	\$\$\$	\$	\$\$\$	\$\$\$\$	Land use and values Predator activity	
Landfill usage	\$10-500	\$\$	\$\$\$	\$	\$	\$\$	\$\$\$	Municipal costs Management costs	
Open burning	\$200-725	\$	\$	\$\$\$	\$\$\$\$	\$\$\$	\$\$\$\$	Disposal of ash Permit Fees	
Fixed-facility incineration	\$35-2000	\$\$	\$\$\$	\$\$	\$\$	\$\$	\$\$\$	Disposal of ash Permit Fees	
Air-curtain incineration	\$140-510	\$\$	\$\$	\$\$	\$\$\$	\$\$	\$\$\$	Disposal of ash Permit Fees	
Bin- and in-vessel composting	\$6-230	\$\$	\$	\$\$\$	\$\$\$	\$	\$\$	Land use Time efficiency	√
Windrow composting	\$10-105	\$	\$	\$\$\$	\$\$\$	\$	\$\$	Land use Time efficiency Predator activity	√
Rendering	\$40-460	\$\$	\$\$\$	\$	\$\$	\$	\$\$	Biosecurity risk	√
Fermentation	\$65-650	\$\$\$\$	\$	\$\$	\$\$	\$	\$	Time efficiency	√
Anaerobic digestion	\$25-125	\$\$\$\$	\$	\$\$	\$\$	\$	\$	Time efficiency	√
Alkaline hydrolysis	\$40-320	\$\$\$	\$\$	\$	\$\$	\$	\$	Disposal of effluent	

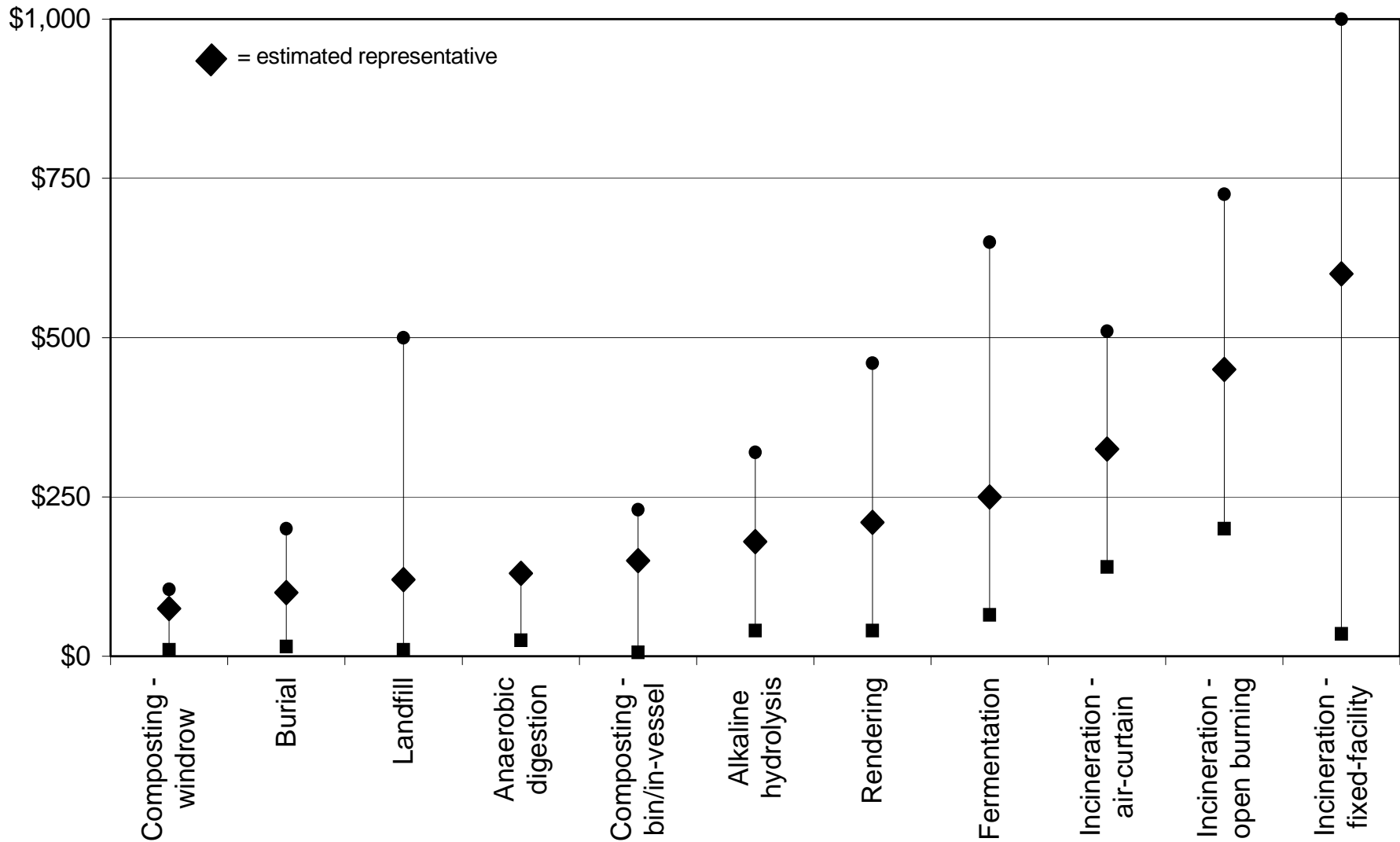
^aThese estimates are the result of an extensive literature review which utilized numerous sources. The data available is based on a variety of assumptions, including differing circumstances, cause of death, scale of disposal efforts, species, dates, and geographical locations. In addition, different cost estimates do not consistently incorporate capital, transportation, labor or input costs.

^bIncludes capital costs directly associated with carcass disposal only.

^cTransportation costs depends on the location of the technology. These indicators assume minimal transportation for more likely available technologies.

SOURCE: *Carcass Disposal: A Comprehensive Review*, chapter 9, p. 22

**Disposal Cost (USD) Per Ton of Carcass Material
(estimated range and representative costs)**



Technology Comparisons

- Important to consider a variety of factors when comparing & contrasting disposal options

Method	Cost	Environment	Perception	Complexity	Total Score
On-site burial	2	2	3	1	8
Landfills	3	2	2	1	8
Incineration	3	2	3	3	11
Composting	1	1	1	3	6
Rendering	1	1	2	1	5
Alkaline Hydrolysis	3	2	2	2	9
In-situ plasma Vitrification	3	1	2	1	7

(Brglez, 2003; point scale 1=good, 2=average, and 3=poor)



Key Conclusions

- Realization of a rapid response requires emergency management plans that are rooted in a thorough understanding of disposal alternatives.
- **The most effective disposal strategies for large-scale events will be those that exploit every available and suitable disposal option to the fullest extent possible.**
- For a multi-dimensional enterprise such as carcass disposal, it's imperative to capture and systematize the relevant dimensions at stake (e.g., environmental considerations, disease agent considerations, availability of the technology, geographical considerations, cost, etc.)



Carcass Disposal: A Comprehensive Review

2002-2004

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Consortium Partners:

Kansas State University

Purdue University

Texas A&M University

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Available online: <http://fss.k-state.edu/research/books/carcassdisp.html>



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