Vegetative Environmental Buffers & Air Quality

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Photo: J. Lorimor; photoshop manipulation J. Tyndall
Presentation Outline

• Major functional goals of VEB’s
• VEB and odor dynamics
• Current research – at Iowa State University
• Current extension – at ISU
• Iowa hog producer demand for VEB’s
Goals of Vegetative Environmental Buffer

1. Visual screen
2. Vegetative filter
3. Windbreak + Shade
Odor / VEB Dynamics

**Odor**
- Ground level emissions
- Limited plume rise
- Spatial & temporal variability
- Particulates & Odor

**VEB’s (15’ +)**
- Dilution
- Particulate Interception
- Deposition
- Aesthetics

Single row, 8 yr old Austree Willow Odor Buffer, Winterset, IA

Photo: J. Tyndall
Unabated Odor Plumes (Particulates)

Prevailing winds

Naturally Ventilated Swine Barn

Computer simulation by Lammers et al., 2001
Simulation of Odor Dilution Process

Prevailing Winds

Computer simulation by Lammers et al., 2001
Simulation of Odor Dilution Process

Prevailing Winds

Zone of vertical mixing dilution

1-2 H above ground level

Zone of slower odor release

Shelterbelt

Adapted from Raine (1974) as used in McNaughton (1988)

Note: Overlay not to scale
Physical Interception of Dust

poultry building ventilation
dust on W. Cedar

Photo: J. Tyndall
Physical Interception of Dust

- 90% odor particles ≤ 5.2 μm
- Odor particles are irregular in shape
- Not just leaf surfaces
- Precipitation can wash trees surfaces

poultry building ventilation
dust on W. Cedar

Photo: J. Tyndall
Aesthetics & Odor Perception

Studies have shown that:
As farm “attractiveness” \(\uparrow\)
odor offensiveness \(\downarrow\)

Out of sight out of mind:
Softening visual cues

Photos: J. Lorimor (ISU)
Aesthetic Focus Group Findings: Iowa Pork Consumers Summer 2004

Iowa:

- High preferences for more trees in Iowa landscape.
- High agreement that shelterbelts improve aesthetics of confinement production.
- High appreciation for “visual” response to odor issues.
Planned Facility Site

Simulations courtesy of B. Malone, U of Delaware
Building, Year 1 planting

- (3-4 year old Red Cedar Stock)

Simulations courtesy of B. Malone, U of Delaware
Year 5

Simulations courtesy of B. Malone, U of Delaware
Year 10 - 15

Simulations courtesy of B. Malone, U of Delaware
Odor Mitigation

- VEB’s provide incremental reductions in odor
- “suite” of odor management strategies

Reductions in:
- Frequency
- Intensity
- Duration
- Offensiveness
Other Benefits of VEB’s

- Size Neutral - Large or small producers
- User Neutral – Tech & public
- Can help with all sources of odor
- Comparatively very inexpensive.
- In theory – increased effectiveness over time
Current ISU Research

- Two USDA NRI grants ($790,000):
  - Bio-physical & Socio-economic
- Multi-State/ Institution
- Partners: Penn State University and the University of Delaware
“Before & After” VEB Field Study

Air samples:
- Odor
- Ammonia
- PM 10
- PM2.5
Sparboe Pullet Facility, Eagle Grove, IA - 2005

Photo: J. Love, ISU
What's next research-wise?

- Field research provided baseline data for wind tunnel testing – Summer ‘07
- National Pork Board funded – Additional wind tunnel studies @ USDA ARS – NTL; Sept ‘07

Previous Wind Tunnel Conclusions -
Up to a 56 % reduction in off-farm dust movement

ISU – Laird and Thernelius, 1997
Extension

• Expanding program

• 2 Web sites coming –
  – Research
  – Extension

• Site visits
  – Basic designs
  – “Do no harm”
  – General advice

• Workshops
Tunnel Ventilation

- Goals of producer
- Functional Zones
- Create no hazards

- Not to scale
- Snow Deposition zone – min 150’
- Min 10 x diameter of fans
- Access Road
- Main Highway
- Tunnel Vents
- Concrete Manure Store 100’x15’
- Pit Vents
- Minimum of 10 H between tree row and building

- = R. Osier Dogwood
- = E. Red Cedar
- = Austree willow

- June – Aug
- Nov – Feb

Wind rose for Central Iowa
Main summer wind filter zone and winter windbreak
Min 150’

Snow deposition area

Access road

Hog Building

Pit vents

Minimum of 10 H between tree row and building

Wider spacing between trees (25’+)

Not to scale

Natural Ventilation

- Goals of producer
- Functional Zones
- Create no hazards

= R. Osier Dogwood
= E. Red Cedar
= Austree willow

Wind rose for Central Iowa

June – Aug  Nov – Feb
Some visual screening from B.Woods Rd N – might cause snow probs

Visual screening

Artificial wind screen can be within about 5-10 times diameter of vent fan without back pressure.

Winter Snow deposition Zone & Summer odor filter

≈ 155' from access rd
≈ 60' b/w rows
≈ 55' from access rd

This row is about 8 – 9 H at maturity; if summer wind is needed move back 80 – 100 ft

≈ 55' from rd.

≈ 40' b/w row & building

E. Wind

block

= Austree Willow
= E. Red Cedar
= Red Osier Dogwood
Row closest to building - Austree Willow - Visual Screen; Life span 15-20 years. Outside row – Concolor or Norway Spruce 20 – 30’ in 20 years
Silver Maple: Near-by market. High Demand = High Stumpage Rates
15 - 20 year rotation - $3,500 - $5,200.
Proper site prep will:

- **↓ Tree Mortality**
- **↑ Tree Growth** (upwards of 70%)
- Ultimately **↓** time, $, and effort.

1 Yr Before:
- 4’ Kill strip (e.g. Round Up)
- Disk/cultivate (work soil to 8” depth)

Yr 1 (Spring – late April/Early May)
- Disk/ cultivate again & if possible rototill
- Soil should have no clumps & minimal residue
Tree Care Options: Drip Irrigation

![Diagram of drip irrigation system]

- Water supply
  - Pump
  - Filter
  - Pressure regulator
  - Pressure Gauges
  - Mainline
  - Lateral (dripper line)
  - Tree
  - Emitter

*www.agr.gc.ca/pgra/shelterbelt/shbpub13.htm*
Mulching

Mulching Plants and Shrubs for Growth and Health

Coarse mulch applied at the proper depth allows:
- Oxygen to enter the soil
- Carbon dioxide to exit soil
- Water to reach soil and roots
- Soil to retain moisture

Choose a mulch...
- with consistent color and texture
- that resists compaction
- that resists wind and water erosion
- with a slow rate of decomposition
- that reduces weed growth

Typically apply mulch from 2 to 4 inches deep.
To help reduce rot, avoid piling materials against trunks or stems.

Source: www.hort.cornell.edu
Weed Control Demo
Economics: Cost Details

• Examining upfront costs for site prep, planting stock, planting & maintenance costs over time:

  – Low Cost scenario (≈$0.75/tree) over 20 years:
    • Seedling stock ≈ $0.03/pig produced

  – High Cost scenario (≈$11/tree) over 20 years:
    • Larger, balled and burlaped stock ≈ $0.33/pig produced

• With extensive drip irrigation add ≈ $0.008/pig
Shelterbelt Cost vs. Odor Mgt Expenditures

Seedling Price Scenarios

Data: Tyndall and Grala, 2007 and USDA, 1996

VEB Economics
**Shelterbelt Cost vs. Odor Mgt Expenditures**

**High Price Scenarios**

Data: Tyndall and Grala, 2007 and USDA, 1996
25% of Iowa's Producers WTP = 0

75% of Iowa's Producers are Willing To Pay for VEB's

Iowa Pork Producer Demand Curve for VEB's

Data: Tyndall, 2007

VEB Costs $0.03/ Head

VEB Costs $0.33/ Head

25% of Iowa’s Producers WTP = 0

Iowa Pork Producer Demand Curve for VEB’s
VEB Summary

- Biophysical & Social quantification – “incremental”
  - More research on the way
- Relatively inexpensive – but it is an expense…
  - Cost-share programming important
- Fastest growing application shelterbelts
- More info becoming available form ISU
Thank You for your time!
Are there any questions?

8 Year old Austree Willow
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Fig. 2. The mobile odour generator mounted in the box of a pick up truck.

Fig. 4. Odour plumes on sites 2 and 5: (a) without windbreak (tests 37, 38 and 39) and (b) with windbreak on the site 2 (tests 5, 8, 12 and 16). An odour concentration of 2 Ou m\(^{-3}\) is used to draw the final contour of the odourous zones.
Fig. 7. Effect of tree type on odour plume: (a) site 1 with deciduous trees (test 1) and (b) site 3 with coniferous trees (test 20). The odour generator is 15 m away from the windbreak. An odour concentration of 2 Ou m⁻³ is used to draw the final contour of the odourous zone.
Fig. 5. Effect of windbreak optical porosity on odour plume: (a) windbreak porosity of 55% on site 1 (test 2) and (b) windbreak porosity of 35% on site 2 (test 16). The odour generator is 30 m away from the windbreak. An odour concentration of 2 Ou m$^{-3}$ is used to draw the final contour of the odourous zone.
Introduction

Preliminary research and observations made by farmers suggest that windbreaks placed around livestock production facilities may effectively reduce movement of odors emitted by manure to neighboring properties. Essentially, trees can be ‘put to work’ to reduce the movement of livestock production odor online.

Although the idea of placing vegetative windbreaks and shelterbelts around agricultural buildings and farm fields is not new, additional benefits from farm windbreaks continue to be learned and tested. Windbreaks alone will not prevent odor problems associated with intensive livestock production but may provide farmers with one more tool to help reduce negative visual perceptions and detection of odors by neighbors and surrounding communities.

Figure 1. A windbreak of matured conifers can significantly change the appearance of livestock production facilities and help filter out odor emissions.

An odor-emitting source can include a livestock production barn, manure storage or farm field where manure is being spread. Windbreaks have the ability to reduce odor concentrations significantly at or very near the source, which greatly improves the effectiveness of separation distances.

There are six ways that windbreaks and shelterbelts can reduce the effects of livestock odor and improve visual perception of production buildings:

1. Dilution and dispersion of gas concentrations at odor by a mixing effect created by windbreaks.
2. Deposition of odorous fluids and other aerosols (like snow fence) to the windward and leeward sides of windbreaks.
3. Collection and storage (sink) within tree wood of the chemical constituents of odor position.
4. Physical interception of dust and aerosols odor particles on leaves, needles and branches.
5. Containment of odor by placing windbreaks furthest and parallel to the odor source.
6. Aesthetic appearance.
   - Trees create a visual barrier to livestock barns.
   - Trees can create chopped fields and pastures more pleasing to look at.
   - Trees are an environmental statement to neighbors that the producer is making every effort to resolve odor problems in as many ways as possible.

• Our work here at ISU is the primary reference.