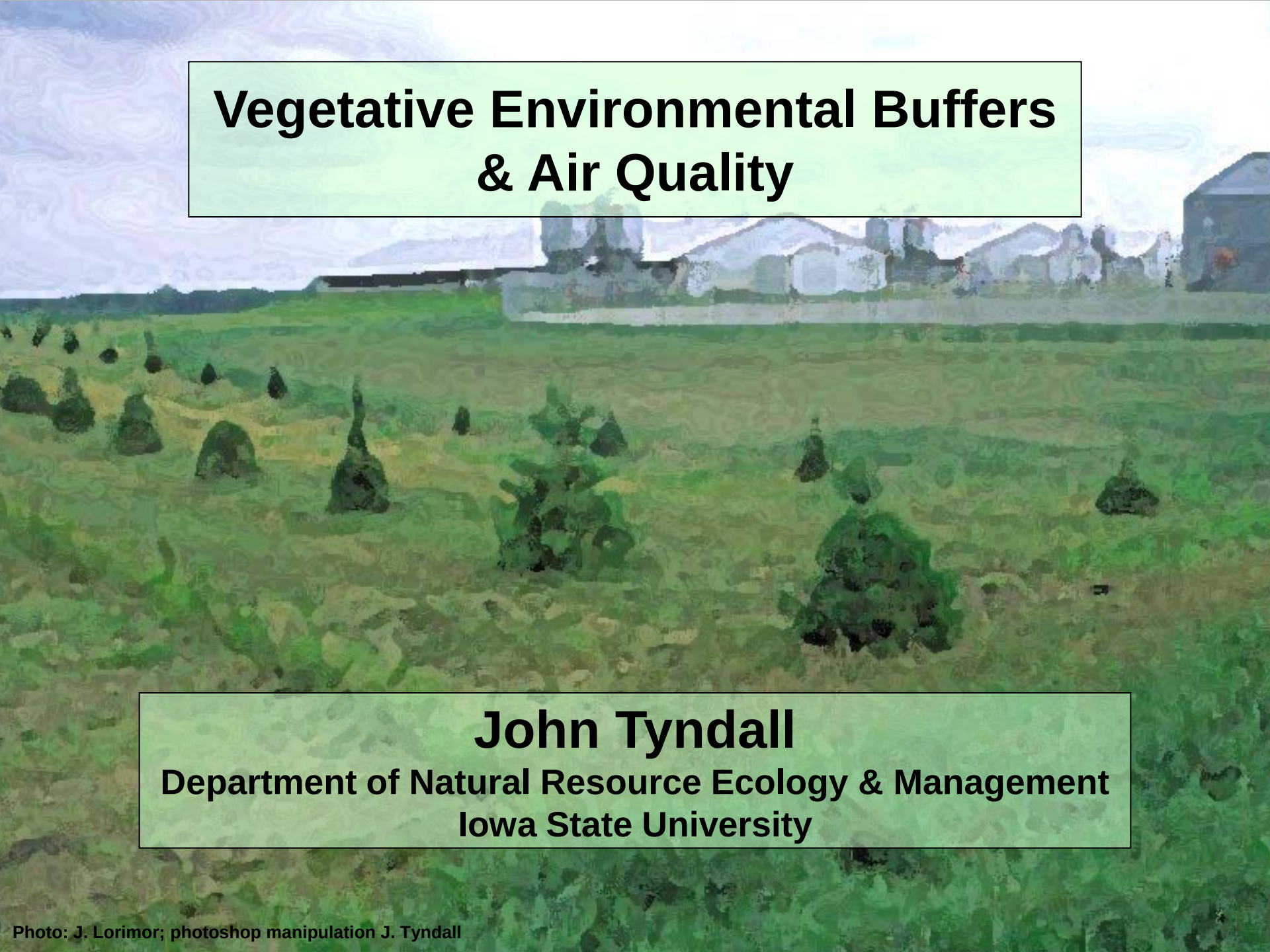
Vegetative Environmental Buffers & Air Quality



John Tyndall

Department of Natural Resource Ecology & Management

Iowa State University

Photo: J. Lorimor; photoshop manipulation J. Tyndall

Presentation Outline

- **Livestock Odor & management**
- **Major functional goals of VEB's**
- **VEB and odor dynamics**
- **VEB management & economics**

Image: Inside agroforestry 2012. 20 (1): 7

Common Pollutants

3,000 + Head Finishing Facility
Central, Iowa

- Odor
- Dust (PM)
- Ammonia (NH_3)
- Hydrogen sulfide (H_2S)

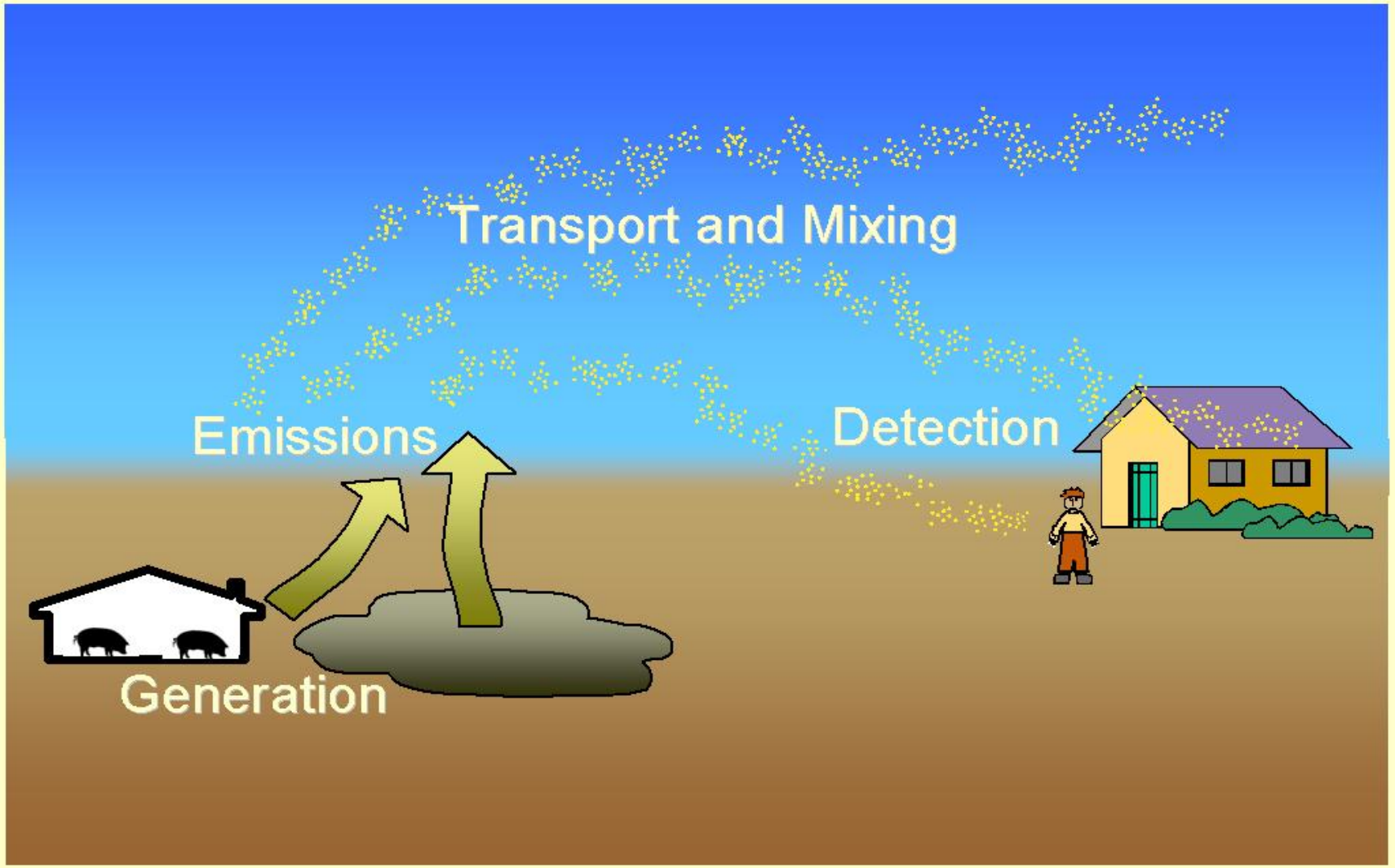
Primary Emission Sources

- Livestock buildings and lots
- Manure and wastewater storage facilities
- Land application

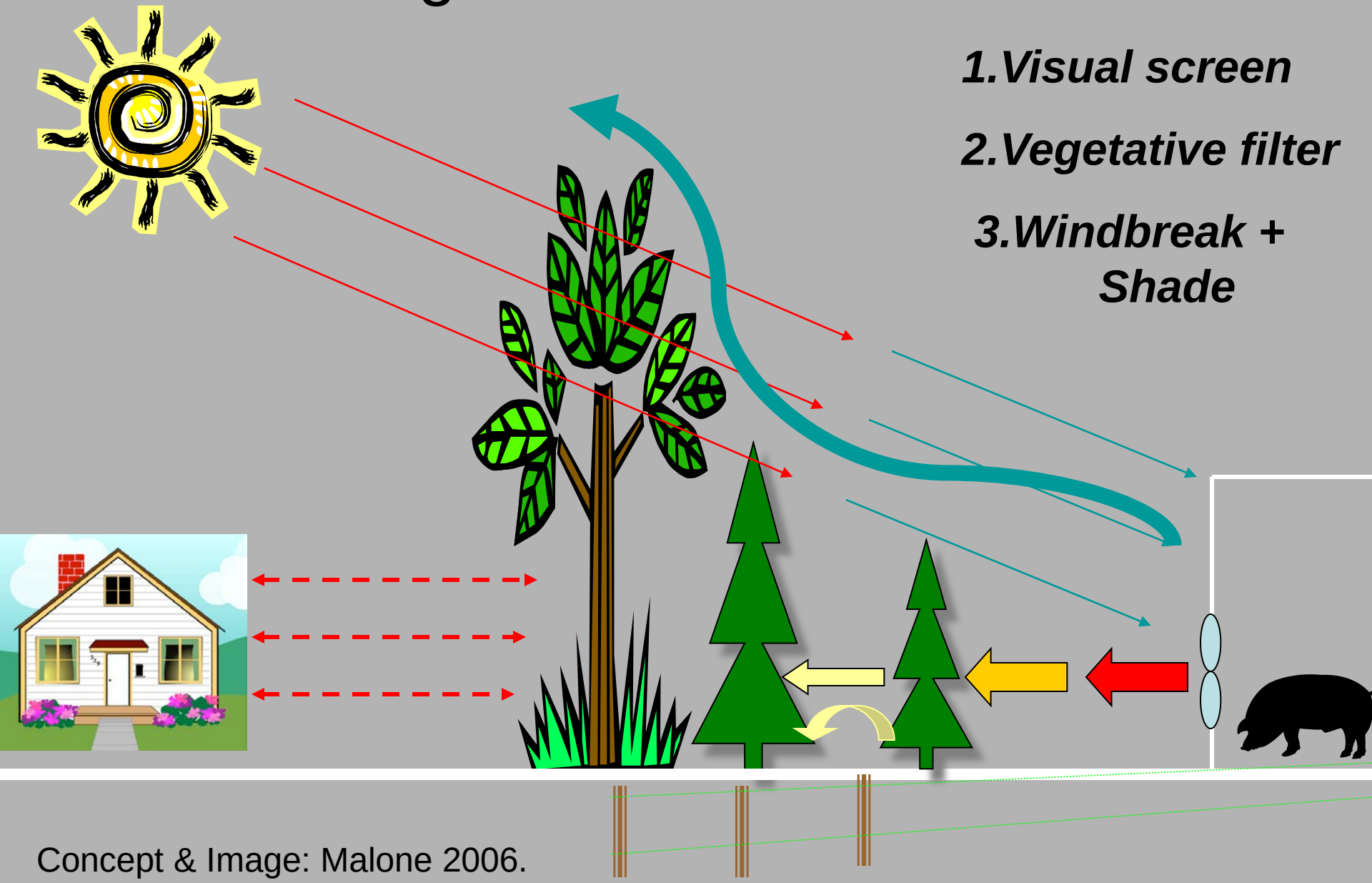
Photos: R. Burns, ISU

Air Pollution Control Points

Odor, Dust, and Chemical Compounds



Goals of Vegetative Environmental Buffer



1.Visual screen

2.Vegetative filter

3.Windbreak + Shade

Concept & Image: Malone 2006.

Odor / VEB Dynamics

Odor

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

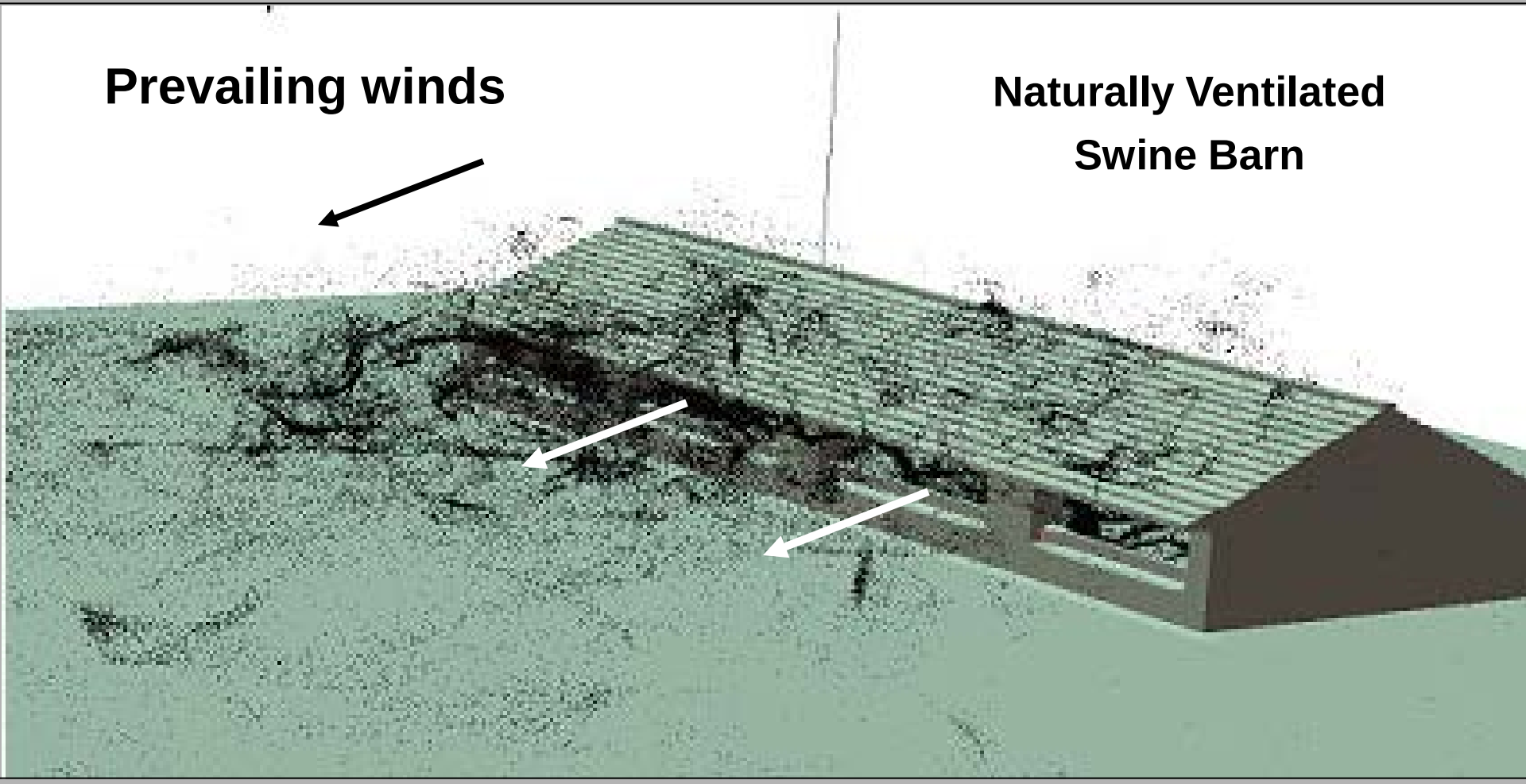
VEB's (15' +)

- **Dilution**
- **Particulate Interception**
- **Deposition**
- **Aesthetics**

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

Photo: J. Tyndall

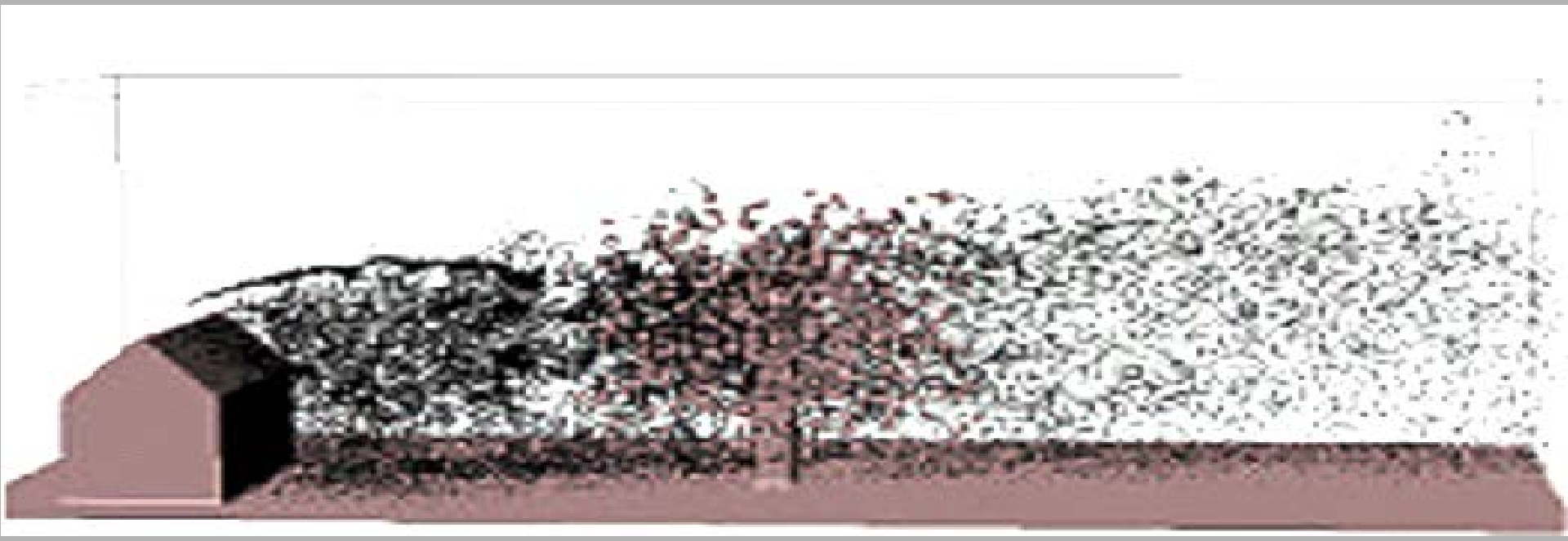
Unabated Odor Plumes (Particulates)



Computer simulation by Lammers et al., 2001

Simulation of Odor Dilution Process

Prevailing Winds



Computer simulation by Lammers et al., 2001

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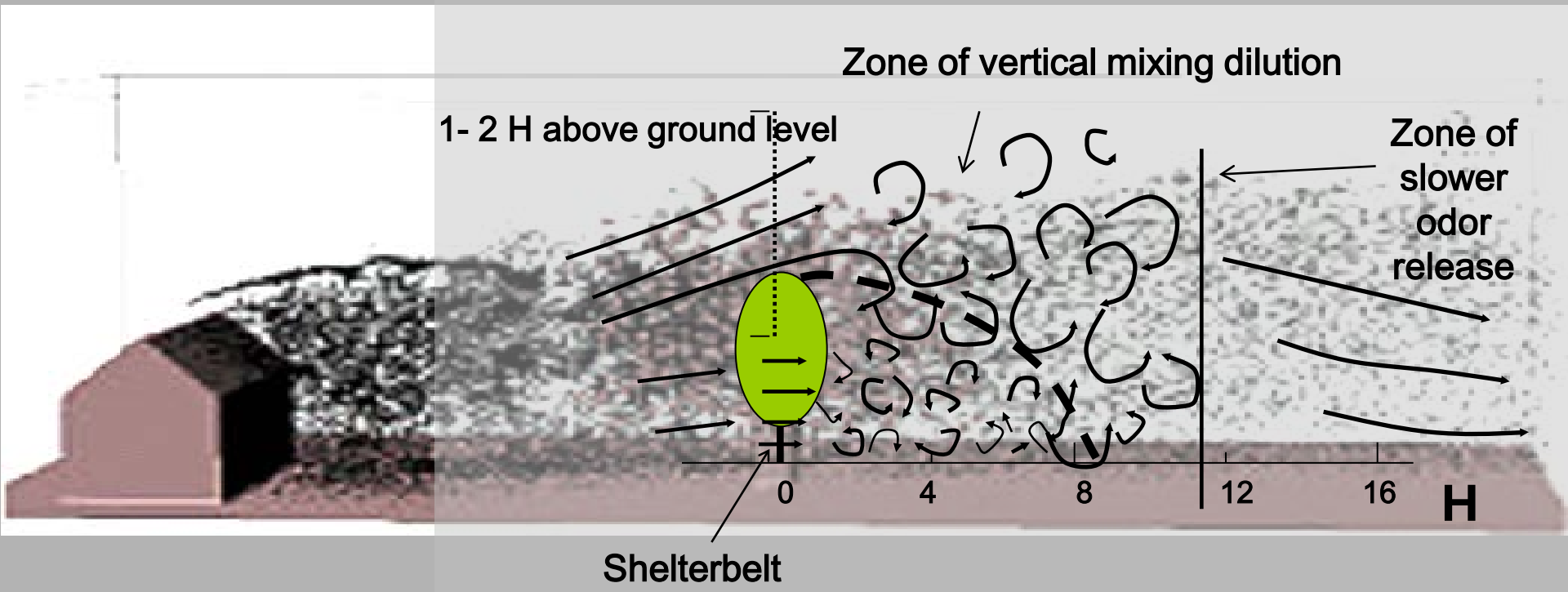
Prevailing Winds



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

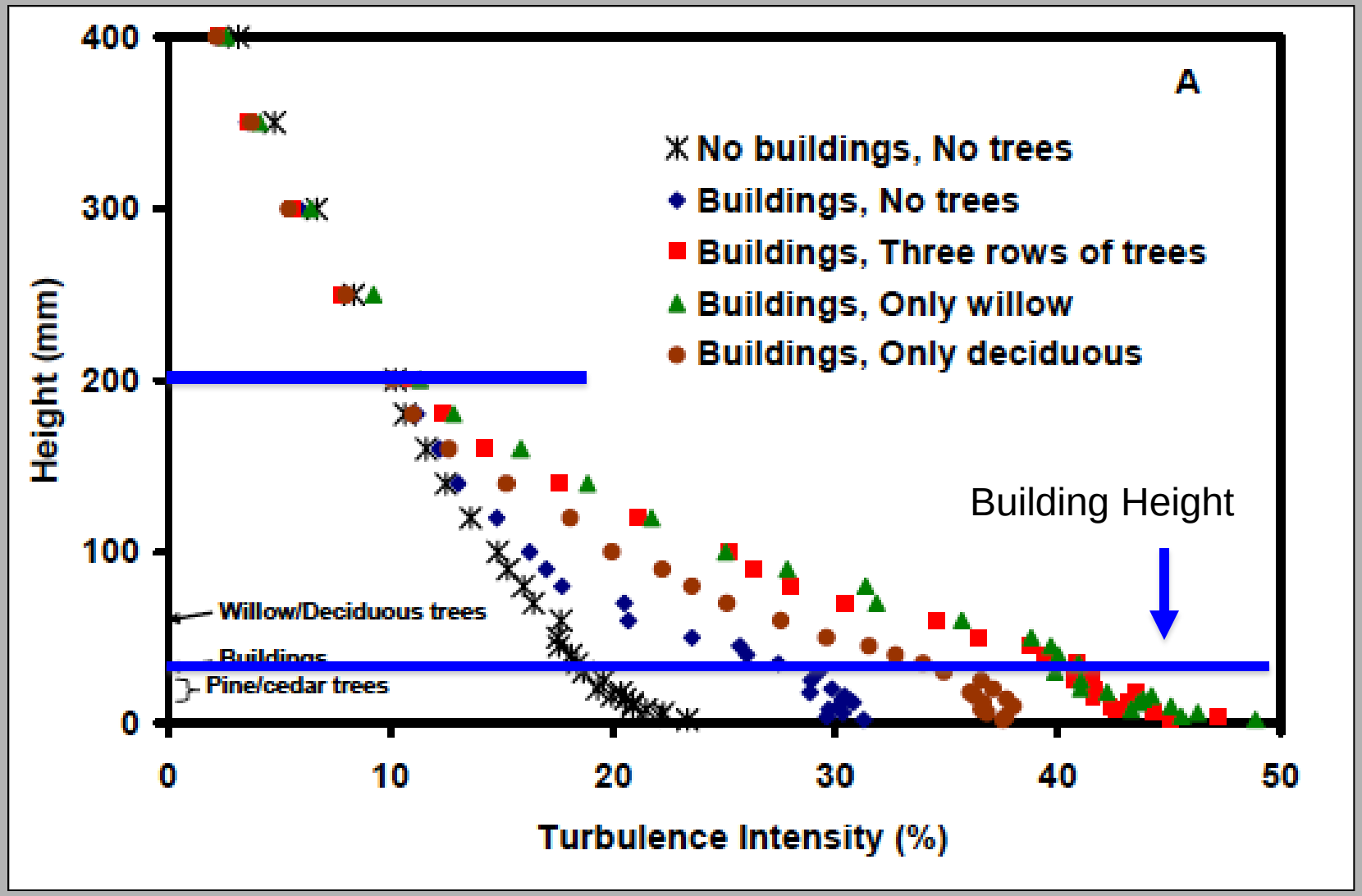
Photo: J. Tyndall

Biophysical Effectiveness

- Tested via models, experiments, & field studies
- **<u>Effectiveness is site specific</u>**: VEB design, ambient weather, topography, direction/ distance to nearest receptor, scale of emissions, manure management protocols followed & other odor mitigation mgt.

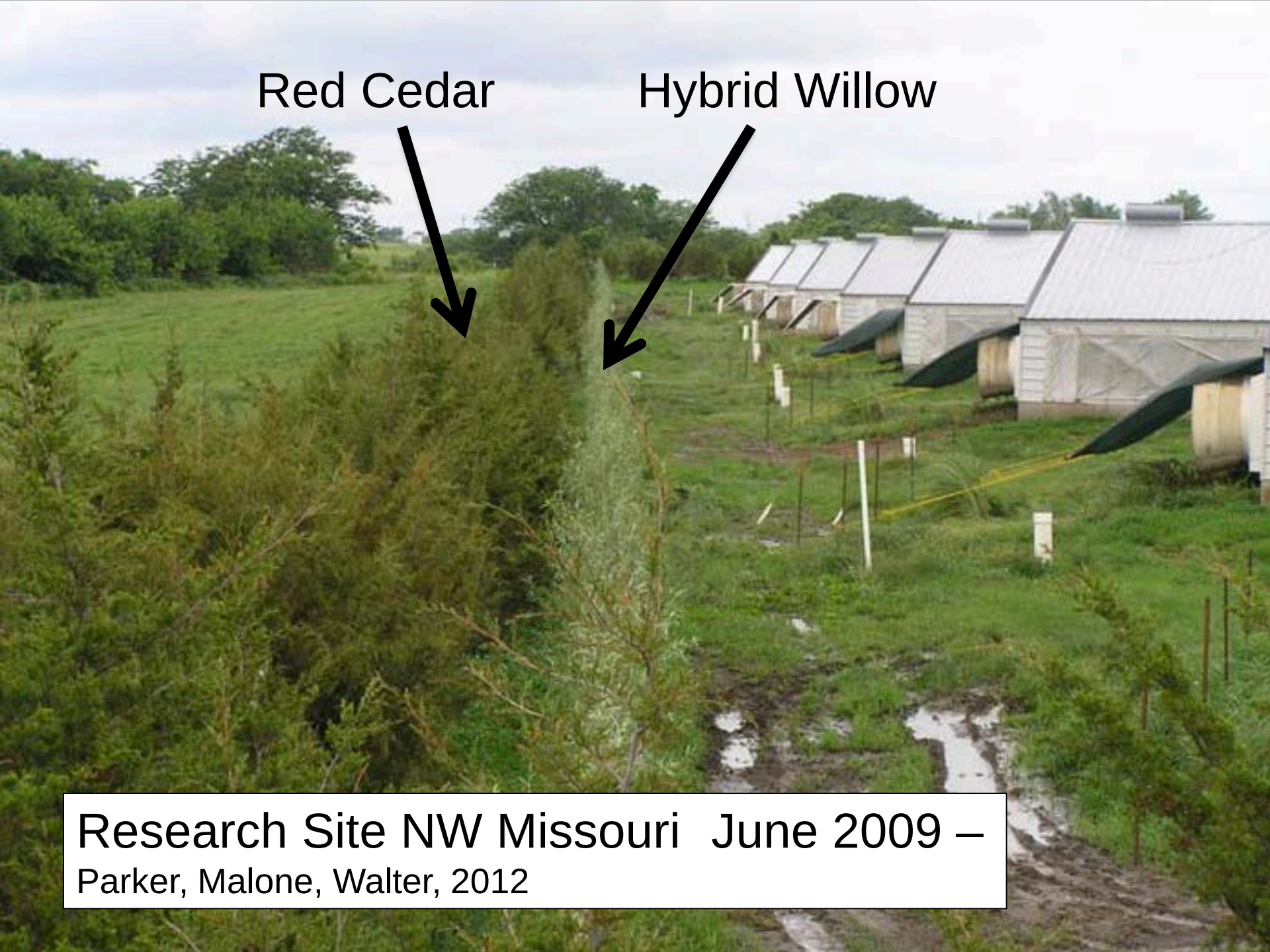
20 foot tall diversion curtains

Wind Tunnel Simulation, USDA ARS



200 mm = 100 feet above ground

Hernandez et al., 2012



Research Site NW Missouri June 2009 –
Parker, Malone, Walter, 2012


August 2009


June 2010

Odor Mitigation

- VEB's provide incremental reductions in odor:

  ~ 5 to 15% range; much higher at times

- "suite" of odor management strategies

Reductions in:

- Frequency
- Intensity
- Duration
- Offensiveness

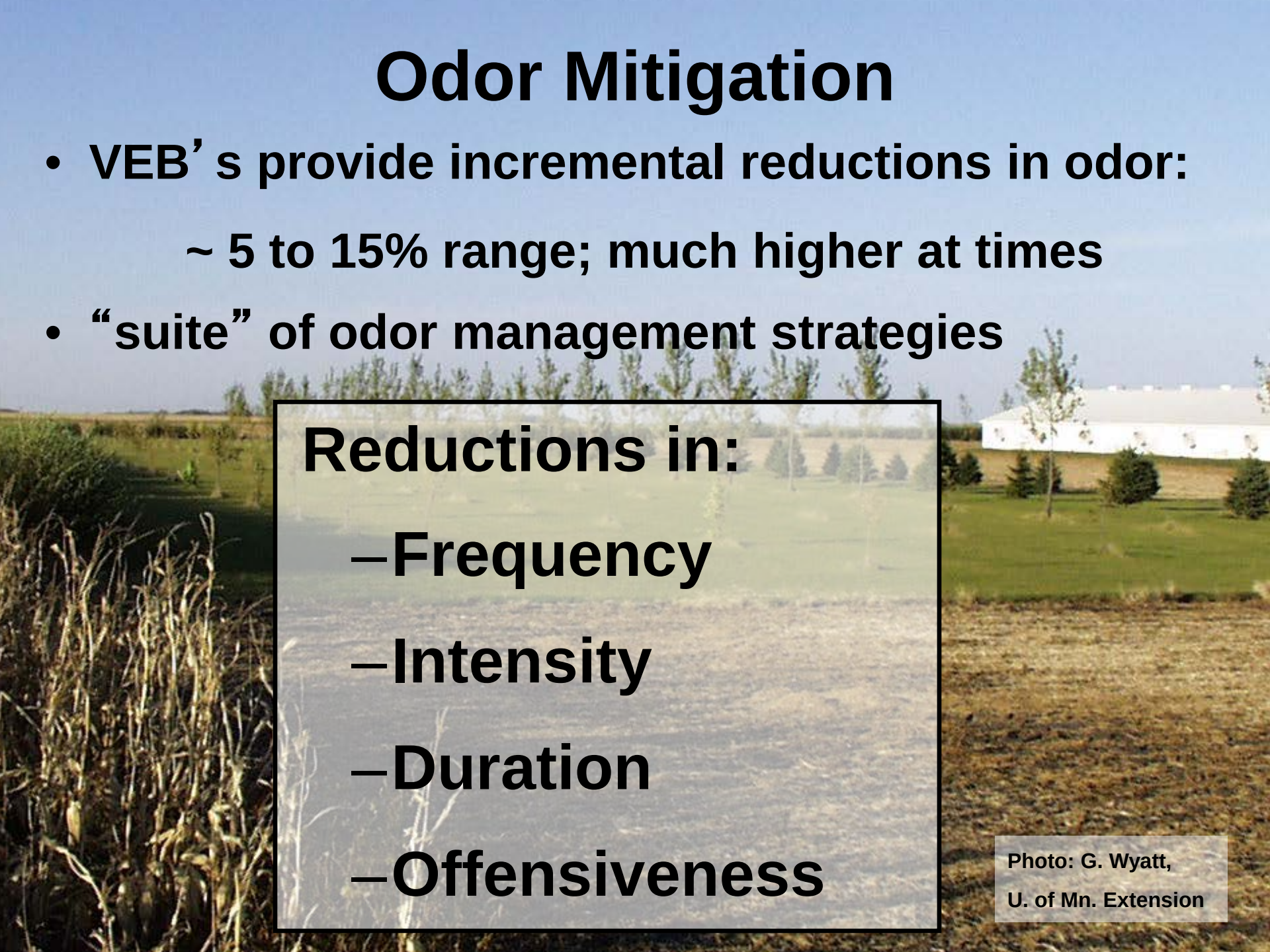


Photo: G. Wyatt,
U. of Mn. Extension


Rose Acres Farm
Winterset, IA


Photos: J. Love, ISU

Aesthetics & Odor Perception

Studies have shown that :

As farm "attractiveness"

↑

odor offensiveness ↓

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.

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**


Photo: TS

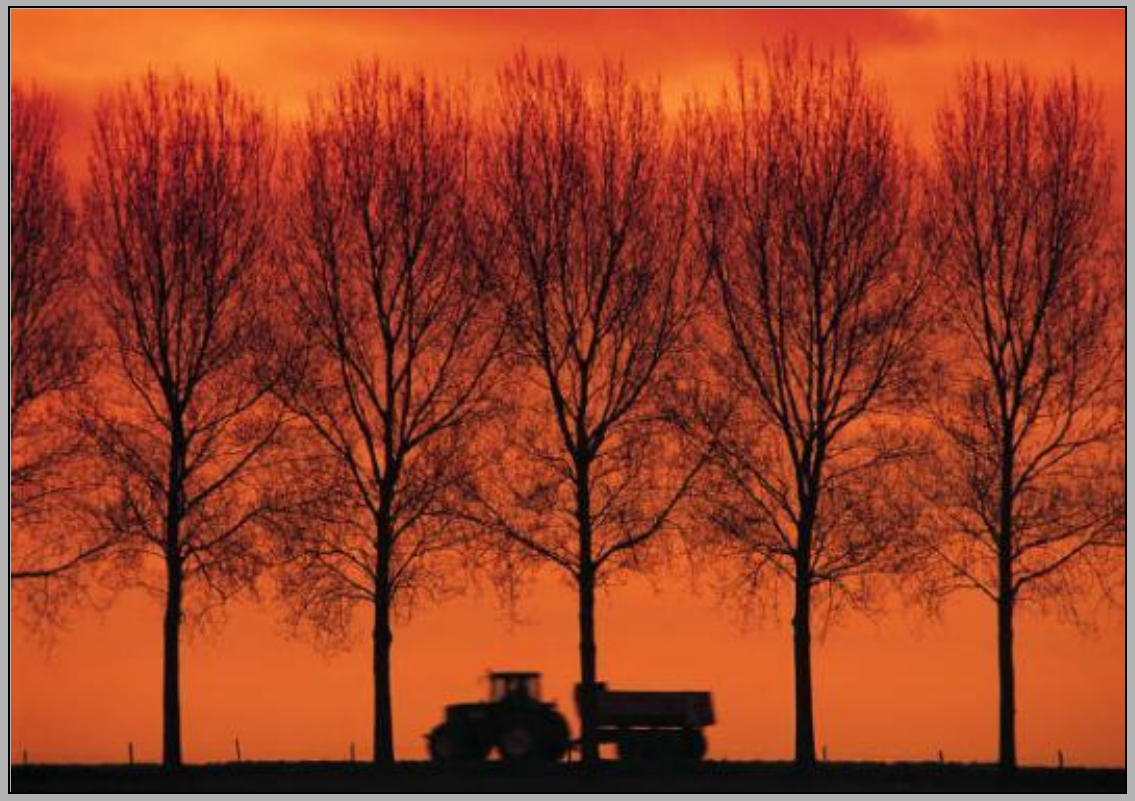

USDA

The Basics of VEB Design

- Site specific designs are best, but…
  - Some generic principles
- Emphasis on
  1. Site Prep
  2. Long-term

First rule of any VEB design…

“Do no harm”



Key Hazards/issues to Consider

Potential Site Hazards:

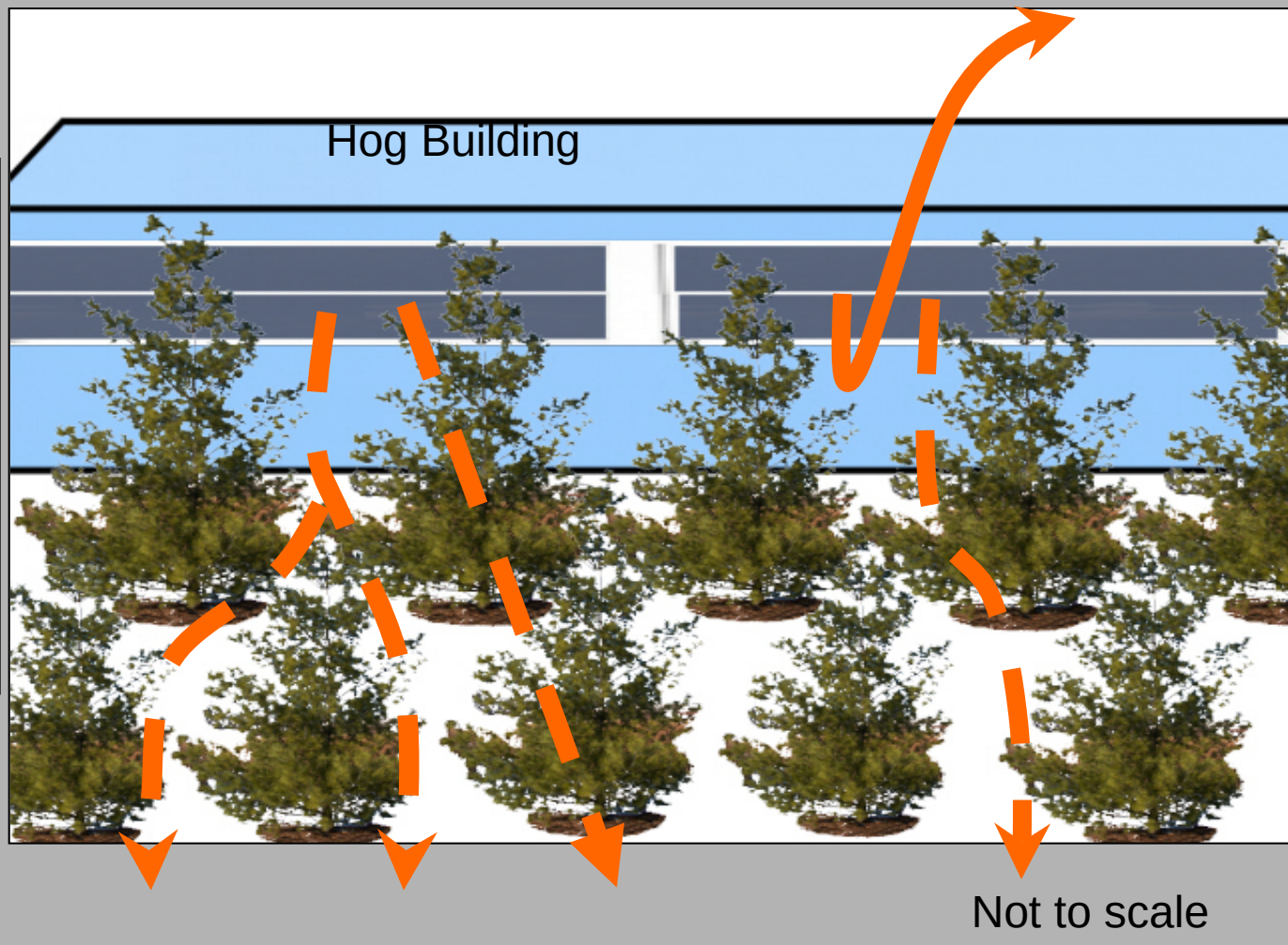
1) Snow
2) Ventilation
3) On-site visibility

Hazard risk changes as trees grow

Tree related Issues:

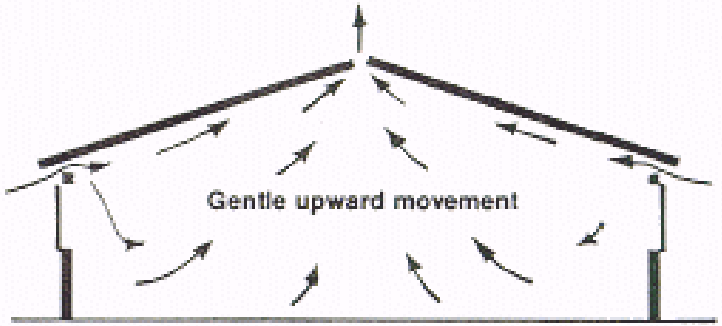
1) Diversity is good within reason
2) Tree health (stock quality, pests/paths)
3) Longevity, species related management

The ideal is to maintain about 40 -50% ***Porosity*** within the VEB: Keys are spacing & tree morphology

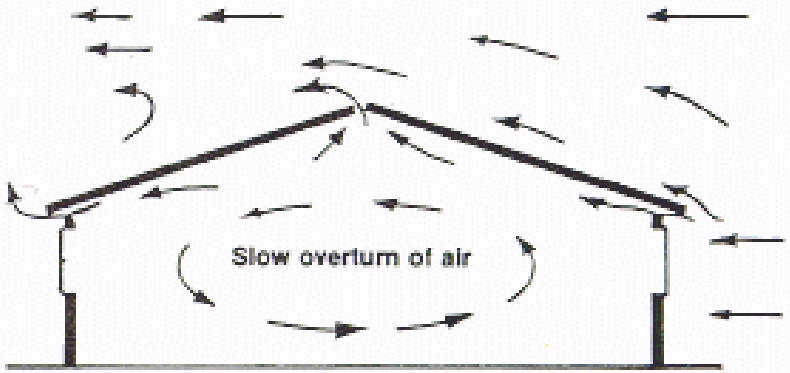


Tunnel Ventilated buildings

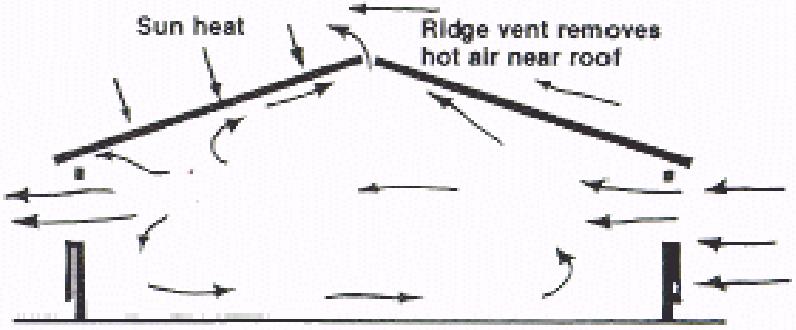
http://www.jordenag.com - Iowa



WINTER VENTILATION—NO WIND OUTSIDE



WINTER VENTILATION—WIND BLOWING

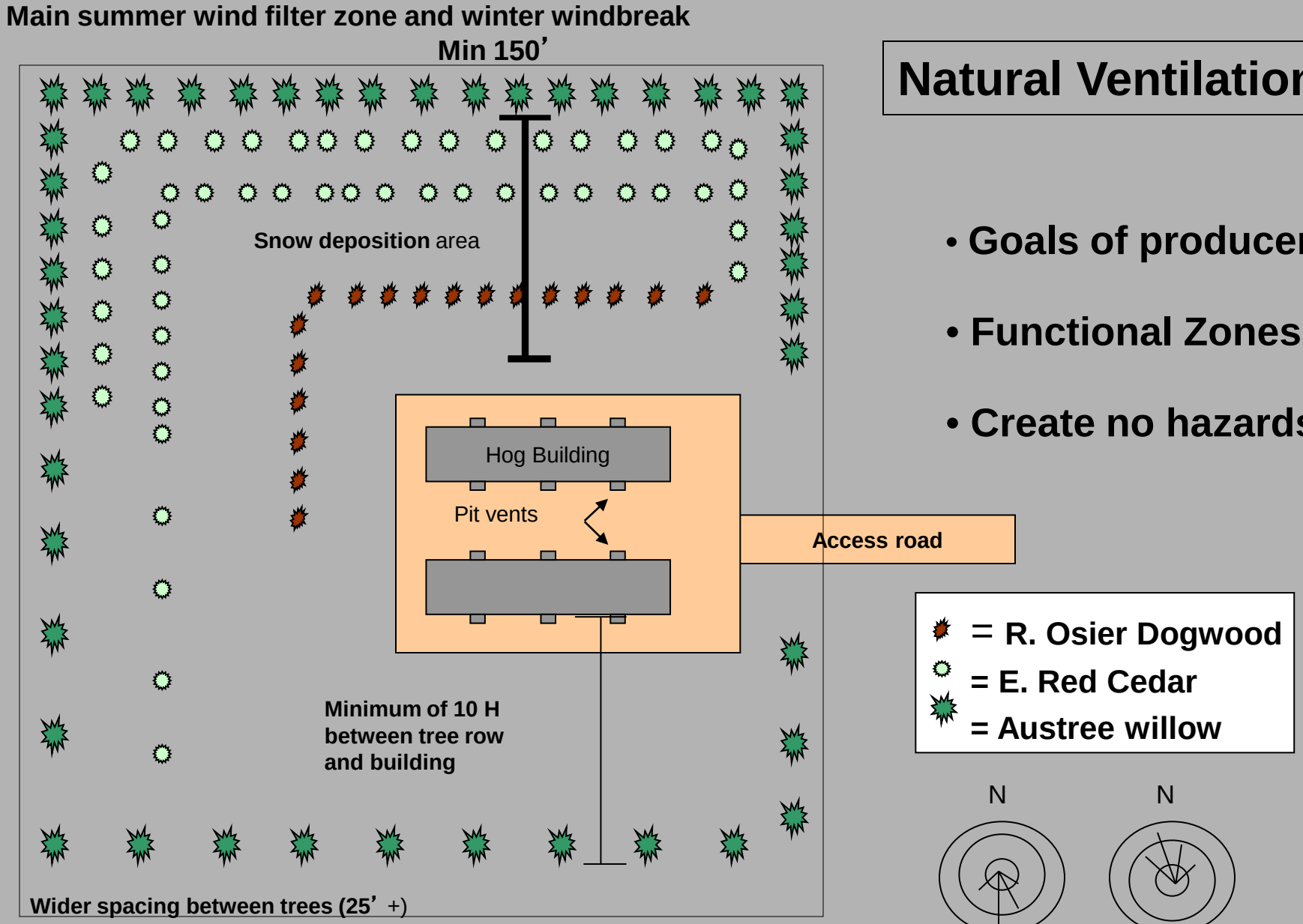


SUMMER VENTILATION—SIDEWALL DOORS OPEN

Naturally Ventilated Side-wall Curtain System

Natural Ventilation

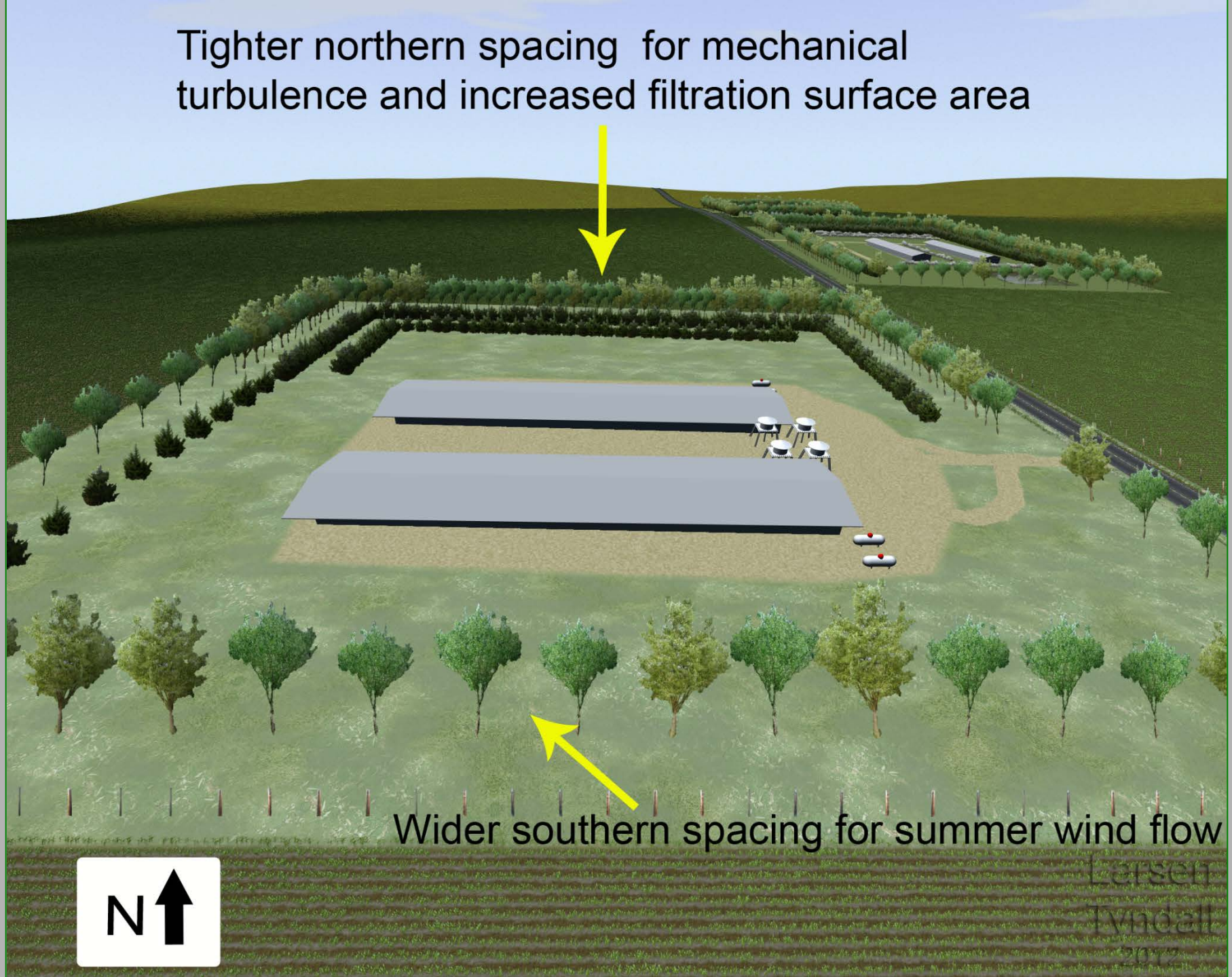
- **Goals of producer**
- **Functional Zones**
- **Create no hazards**

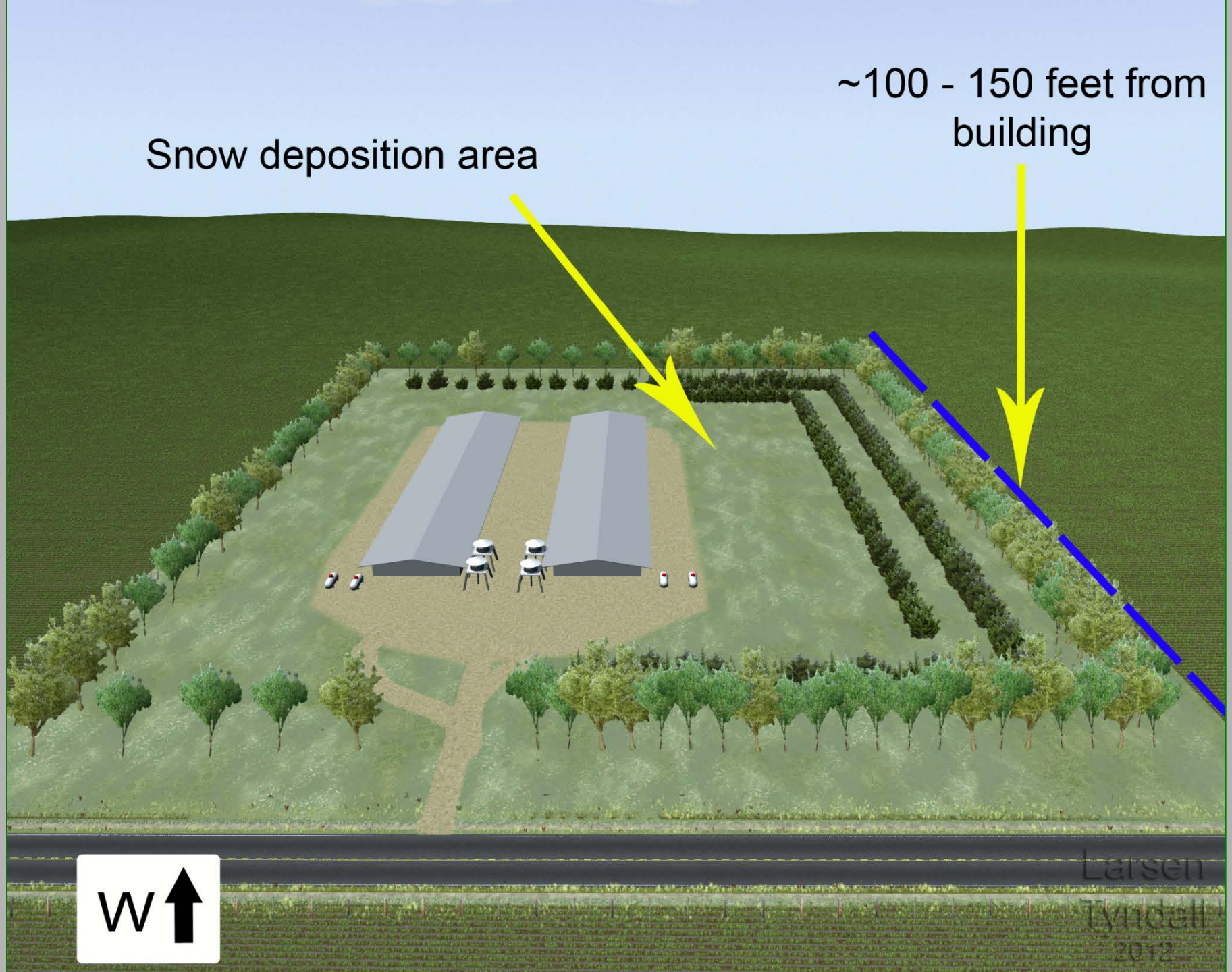


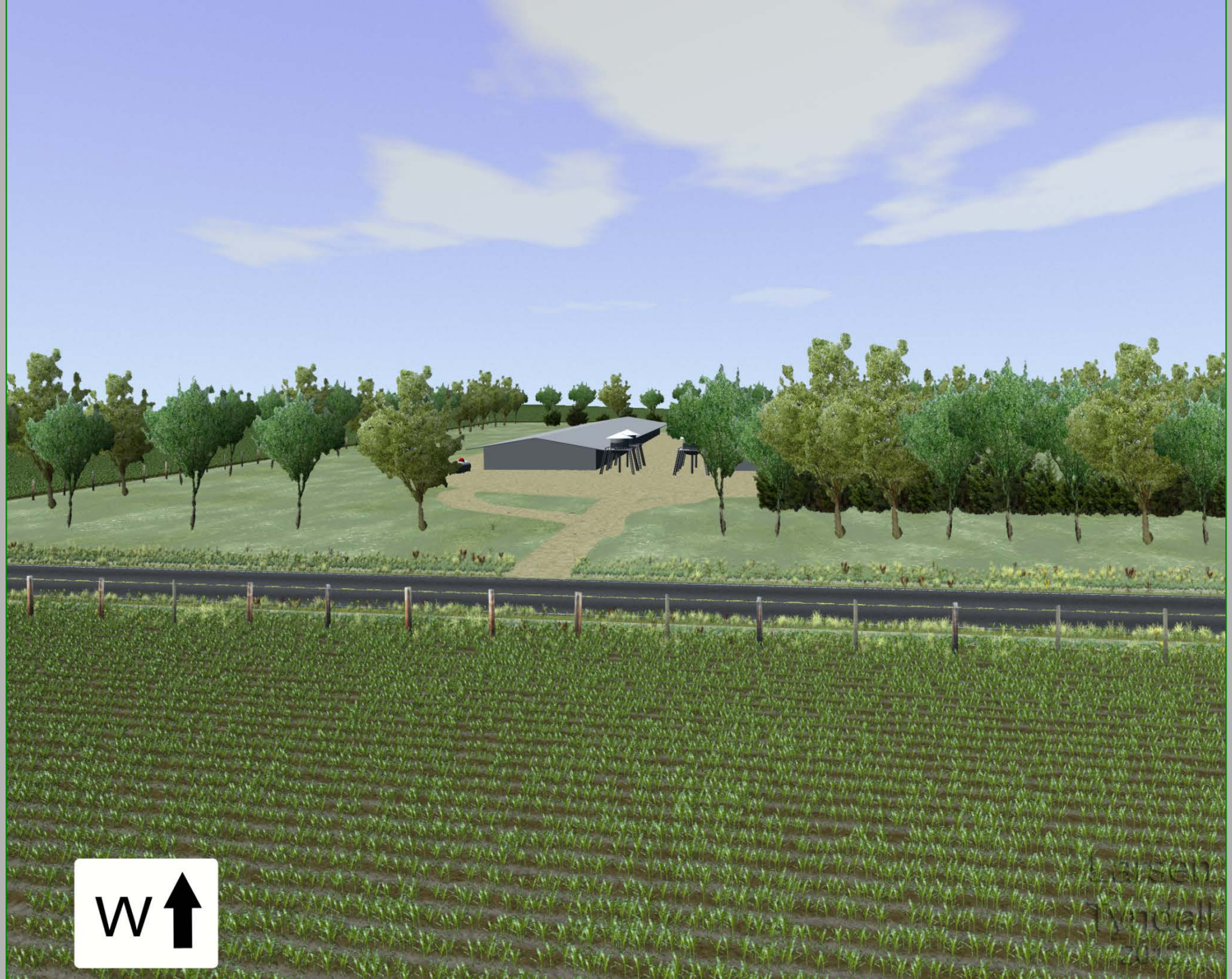
Not to scale

June – Aug Nov – Feb

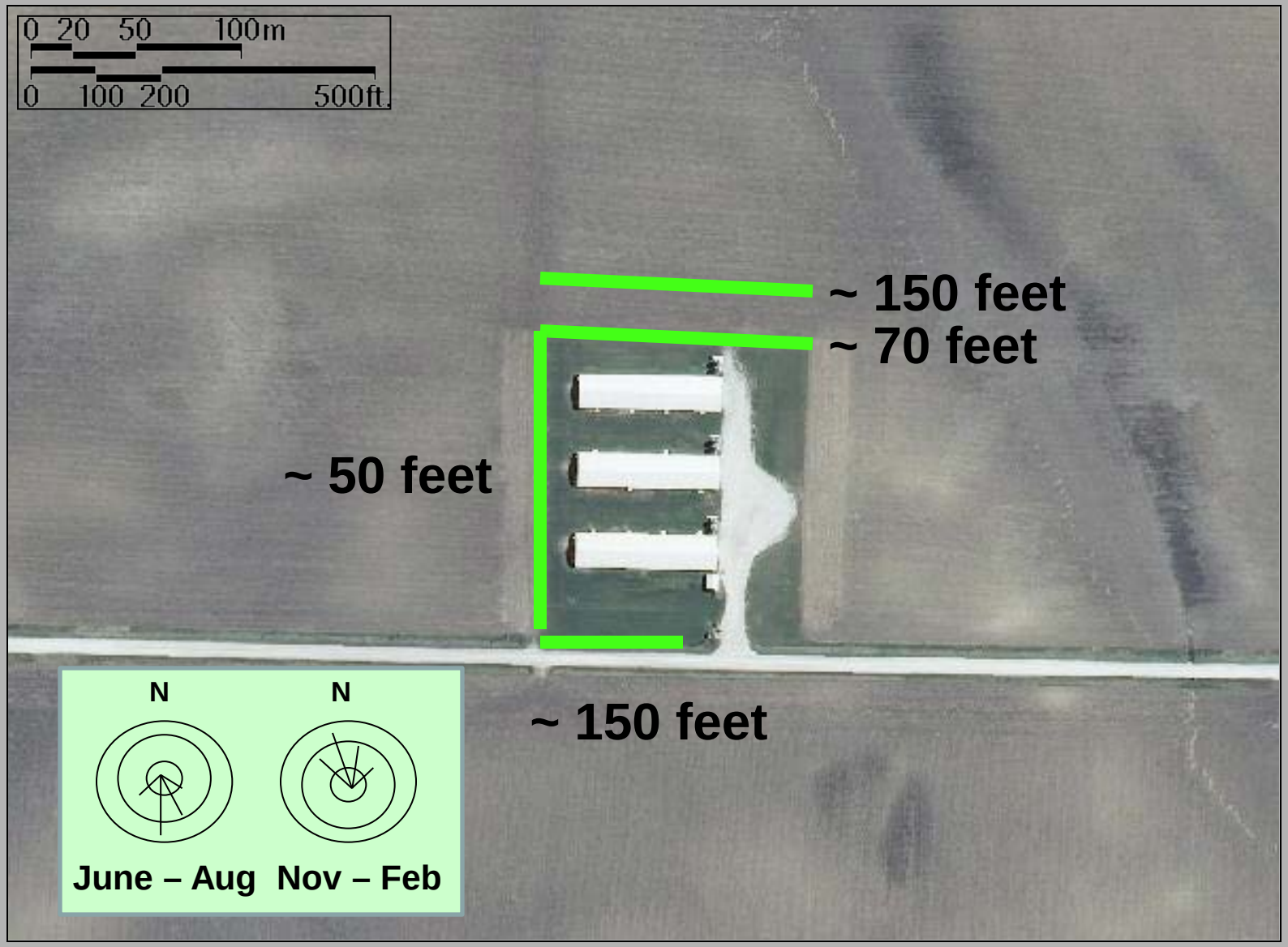
Wind rose for Central Iowa


Tighter northern spacing for mechanical turbulence and increased filtration surface area
Wider southern spacing for summer wind flow
N
Larsen
Tyndall


~100 - 150 feet from building
Snow deposition area
W
Larsen Tyndall 2012


W

A Challenging Site…



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)

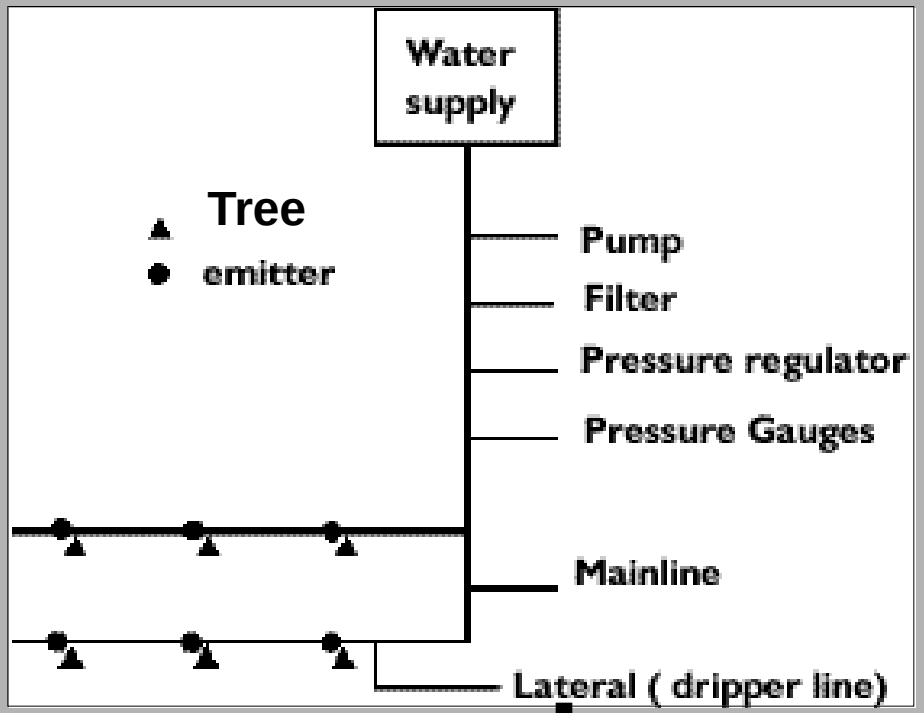
- Yr 1 (Spring – late April/Early May)
  - Disk/ cultivate again & if possible rototill
  - Soil should have no clumps & minimal residue

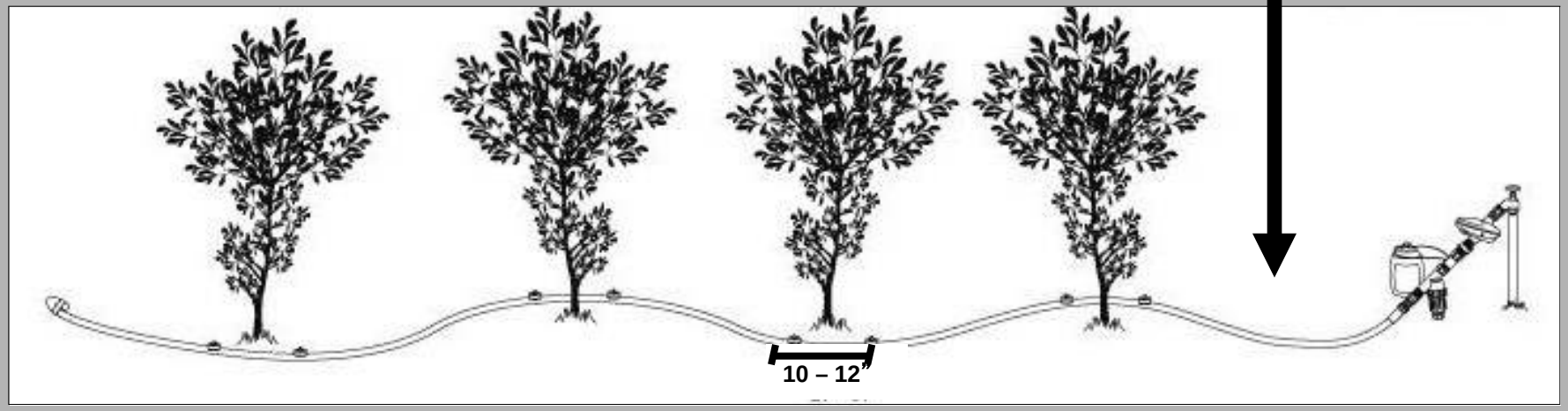
General VEB Care & Maintenance

- Moisture management: drip irrigation, mulch
- Weed control: mowing, chem, “weed mats”
- Gen. Tree replacement: Under normal conditions ≈ 10% mortality/ per year for 3 yrs
- Whole belt replacement: some hybrid poplar sp. ≈ 15-20 yr life span.
- “Nurse” systems
- Herbicide Drift & Herbivory

Malone, 2006

Tree Care Options: Drip Irrigation





www.agr.gc.ca/pfra/ shelterbelt/shbpub13.htm

VEB Costs highly variable & site/ design specific.

There are 3 main categories of expenses:

1) Site prep costs,

2) tree establishment costs, and

3) long term maintenance costs.

Expected Costs for Simple VEB

Averages for Iowa	Without cost-share	With EQIP *
Annualized cost “Low price”	$85	$30
Annualized cost “High price”	$360	$295
Upfront costs – Low price	$ 750	$0
Upfront costs – High price	$3,400	$2,300
Costs/ pig over 20 yr period	$0.01 – 0.03/pig	< $0.01 – 0.02/ pig

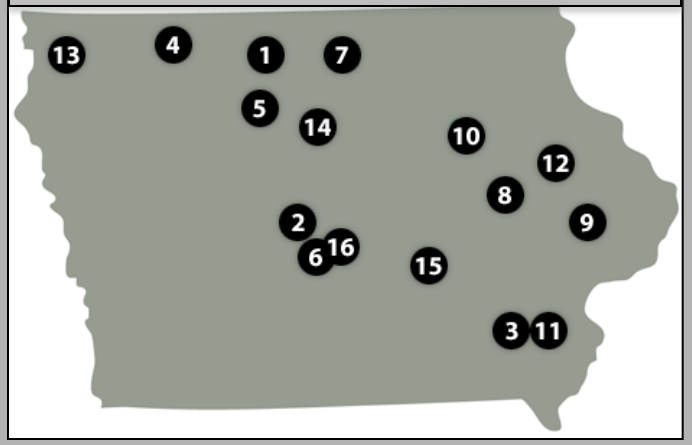
- IA EQIP = $862/acre
- Accounting for land rent will increase costs significantly
- With extensive drip irrigation add ≈ $0.008/pig

VEB Programming

Since 2004, Green Farmstead Partner program has been cost sharing VEB establishment

- Joint effort of Coalition to Support Iowa Farmers, Trees Forever & the Iowa Nursery & Landscape Association
- Sponsor VEB training for Nursery personnel & field consultants

16 tree nurseries now design & establish VEBs



NRCS: VEB = Code 380

Windbreak/Shelterbelt–Odor Control

Conservation Practice Information Sheet ***(IS-MO380)***

Using Windbreaks to Reduce Odors A
Livestock Production Facilit

Introduction

Preliminary research and observations made by farmers suggest that windbre
production facilities may effectively reduce movement of odors emitted by ma
Essentially, trees can be 'put to work' to reduce the movement of livestock pr

Although the idea of placing vegetative windbreaks and shelterbelts around a
fields is not new, additional benefits from farm windbreaks continue to be lear
alone will not prevent odor problems associated with intensive livestock produ
with one more tool to help reduce negative visual perceptions and detection c
surrounding communities.

*Figure 1. A windb
significantly chan
production facilit
particles.*

An odor-emitting
production barn,
where manure is
the ability to redu
significantly at or
greatly improves
distances.

There are six way
shelterbelts can reduce the effects of livestock odor and improve visual perce

1. Dilution and dispersion of gas concentrations of odor by a mixing effe
2. Deposition of odorous dusts and other aerosols (like snow fencing) t
of windbreaks.
3. Collection and storage (sinks) within tree wood of the chemical const
4. Physical interception of dust and aerosols odor particles on leaves, n
5. Containment of odor by placing windbreaks fore and/or aft of the odo
6. Aesthetic appearance:
   - Trees create a visual barrier to livestock barns
   - Trees can make cropped fields and pastures more pleasing to loo
   - Trees represent an 'environmental statement' to neighbors that th
   every effort to resolve odor problems in as many ways as possibl

[1] This information sheet is adapted from the following references: "Using Shelterbelts
Livestock Production Barns" (January 2004) by Todd Leuty, Horticulture/Agroforestry S
and Food. "Air Quality and Shelterbelts: Odor Mitigation and Livestock Production – A
and Joe Colletti; Iowa State University."Designs for Windbreak Walls for Mitigating Dus
Ventilated Swine Buildings" 2000. R. Bottcher, R. Munilla, G. Baughman, and K. Keene

NRCS Missouri 1

Missouri 2004

Illinois NRCS - Windbreaks and Odor Management

Fact Sheet

Using Windbreaks to Manage Odor from Livestoc

Purpose

The purpose of this fact sheet is to help raise awareness of the opportunity to include windbr
of animal production facility odors. Also discussed are factors important to deciding if a wind
well as considerations for design.

Introduction

Over the past few decades, odor management has become an increasingly important issue i
industries nationwide. The face of rural America has changed as production trends have shi
operations throughout the country to greater concentrations of large scale confined animal o
larger animal production facilities producing greater quantities of manure. The increased qu
potential to produce more intense odor, more frequently and for longer duration.

At the same time, more people from urban areas have moved further out into rural areas. Nu
legal actions have arisen throughout the country as a result of concerns about the impact the
quality of life, health, the environment, real estate values, communities and neighbor relation
potential for litigation and conflict has resulted in a greater effort to manage odor emissions f
facilities.

About Windbreaks

A windbreak is a planting of trees or shrubs designed to modify wind flow. NRCS has promoted windbreaks for the better part of the last century for a number of purposes that range from reducing soil erosion from wind, to managing snow, to protecting farmsteads, to storing carbon. Today people are beginning to explore the potential benefits windbreaks have for managing odor.

USDA NRCS Photo Gallery

Windbreaks serve many purposes. They have commonly been used to protect farmsteads and operations from harsh winter winds.

Illinois 2007

United States Department of Agriculture 2012

NRCS Natural Resources Conservation Service

Environmental Quality Incentives Program

Helping People Help the Land • www.ca.nrcs.usda.gov

FACT SHEET - ***WINDBREAK/ SHELTERBELT ESTABLISHMENT AROUND CONFINED ANIMAL FACILITY HEADQUARTERS (Code 380)***

The Natural Resources Conservation Service is offering assistance by encouraging California growers to use new and innovative agricultural emission reduction practices and technologies that provide significant environmental benefits to our natural resources.

This practice provides a payment for establishing windbreaks and shelterbelts around confined animal facilities (CAFs). CAFs are sources of PM10 (particulate matter up to 10 microns in diameter), volatile organic compounds (VOC), and ammonia emissions through everyday animal production activities and the waste they generate.

Windbreaks and shelterbelts can reduce PM10 emissions by intercepting the particulate matter and containing them in the tree vegetation. Odors leaving a CAF are also reduced in areas downwind when a windbreak has been established.

PROGRAM GUIDELINES:
380 - Windbreak/Shelterbelt Establishment
441, 442 - Irrigation Systems (Component Practice)

Program Specifics

California growers must meet eligibility requirements to qualify for payments.

➤ A one-row, two-row, or three-row windbreak/ shelterbelt is eligible.

➤ Trees and vegetation must be irrigated. Proper irrigation systems and installation must be followed per NRCS standards 441 or 442.

➤ Payment for windbreak/shelterbelt is:
- Option 1: One-row windbreak - $1.26/linear foot
- Option 2: Two-row windbreak - $2.52/linear foot
- Option 3: Three-row windbreak - $3.78/linear foot

➤ Payment for an irrigation system on new windbreak planting is $400/acre.

For More Information

For more information about the Environmental Quality Incentives Program, please contact your local USDA Service Center, listed in the government section of the phone book under U.S. Department of Agriculture. Information is also available on the internet at **www.ca.nrcs.usda.gov**.

California 2012

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 of shelterbelts in IA
- More info becoming available from ISU & others

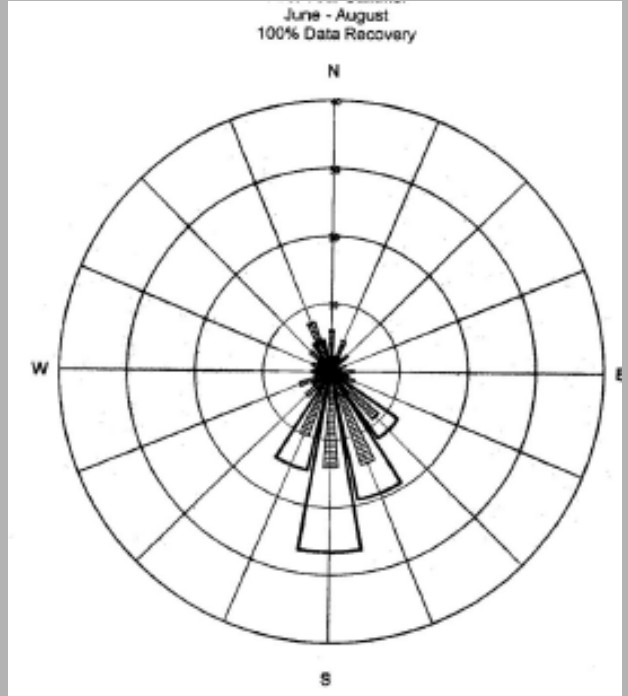
Thank You for your time!
Are there any questions?

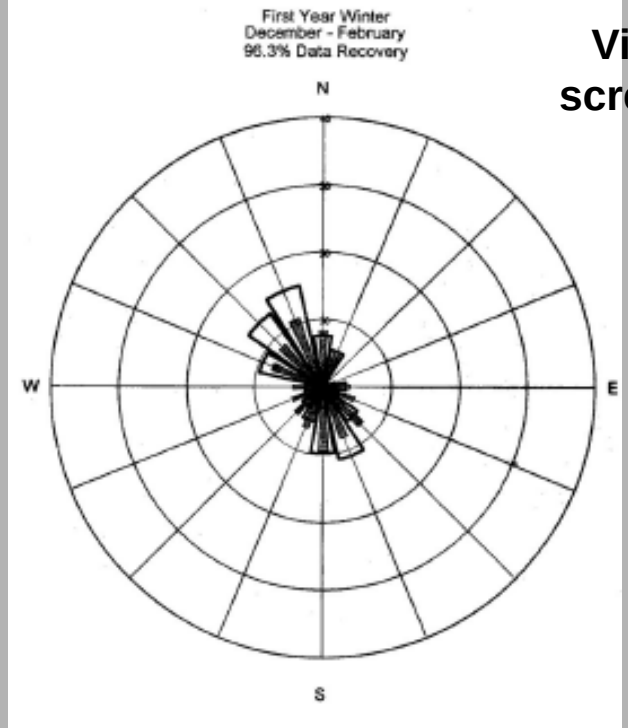
Contact Info:

Dr. John Tyndall

Phone: 515.294.4912

jtyndall@iastate.edu





Some visual screening from B.Woods Rd N – might cause snow probs

N

1

≈40’ b/w row & building

E. Wind
← block

2

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

3

Winter Snow deposition Zone & Summer odor filter

≈ 155’ from access rd

≈ 60’ b/w rows

≈ 55’ from access rd

Visual screening

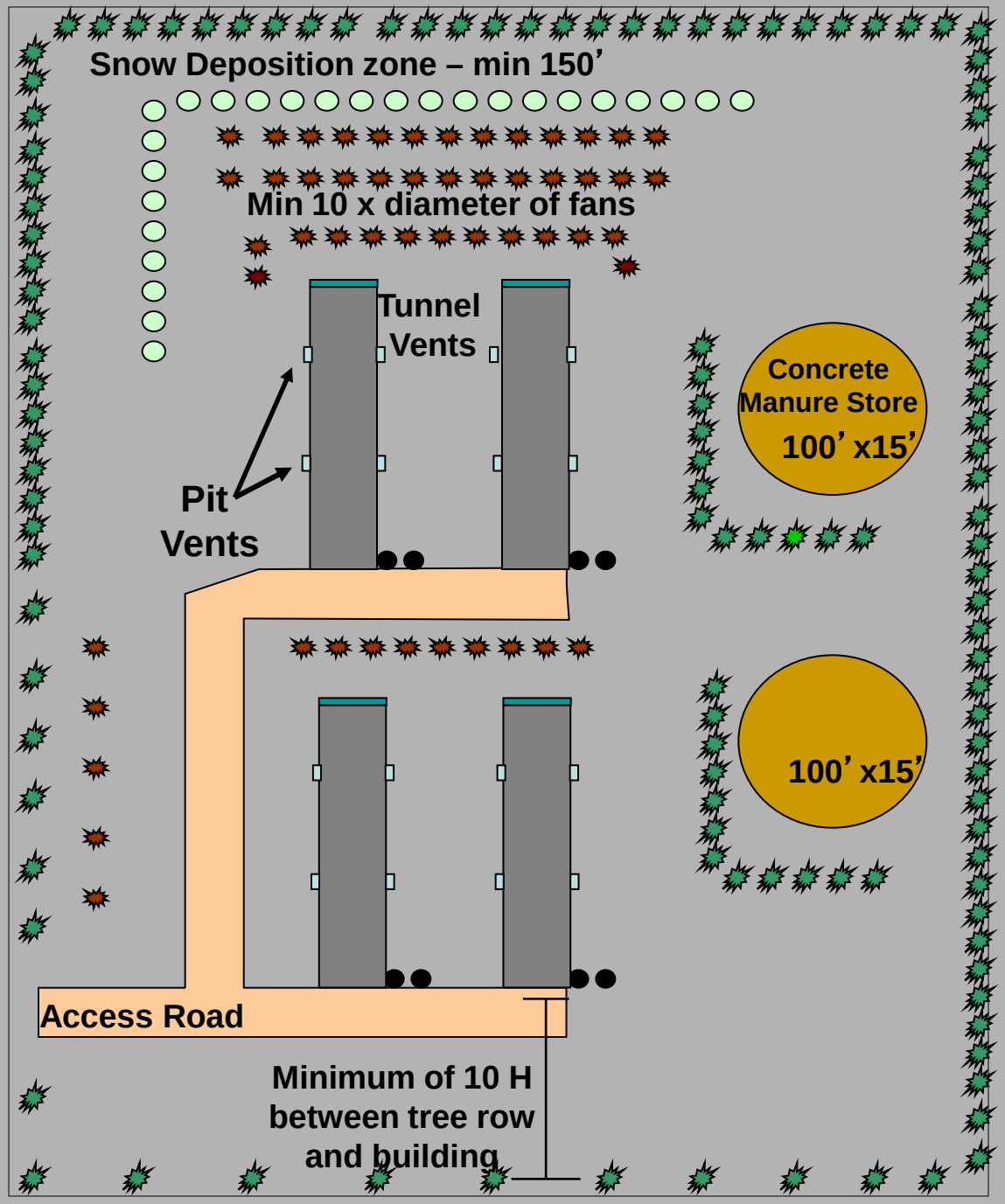
= Austree Willow
= E. Red Cedar
= Red Osier Dogwood

5

4

≈ 55’ from rd.

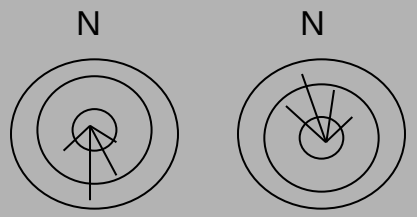
This row is about 8 – 9 H at maturity; if summer wind is needed move back 80 – 100ft



Tunnel Ventilation

- Goals of producer
- Functional Zones
- Create no hazards

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

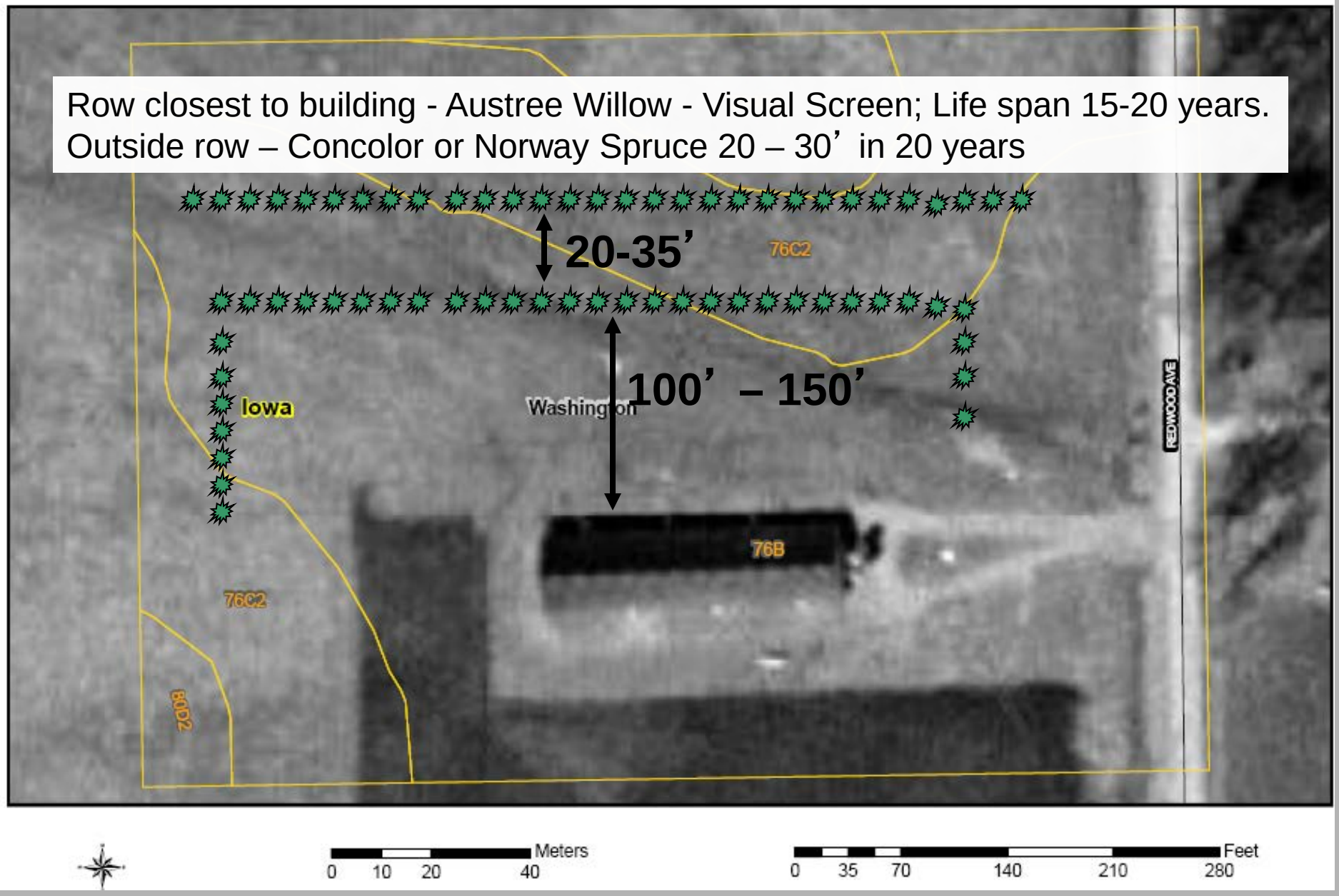


June – Aug Nov – Feb

wind rose for Central Iowa

Not to scale

josh


Row closest to building - Austree Willow - Visual Screen; Life span 15-20 years.
Outside row – Concolor or Norway Spruce 20 – 30’ in 20 years
20-35’
100’ – 150’
76C2
Iowa
Washington
76B
76C2
80D2
REDWOOD AVE
Meters
0 10 20 40
Feet
0 35 70 140 210 280

josh


Silver Maple: Near-by market. High Demand = High Stumpage Rates
15 - 20 year rotation - $3,500 - $5,200.
Iowa
Washington
REDWOOD AVE
76B
76C2
80D2
Meters
0 10 20 40
Feet
0 35 70 140 210 280

≈ 1800’

Site 3 one row of conifers

Fig. 2. The mobile odour generator mounted in the box of a pick up truck.

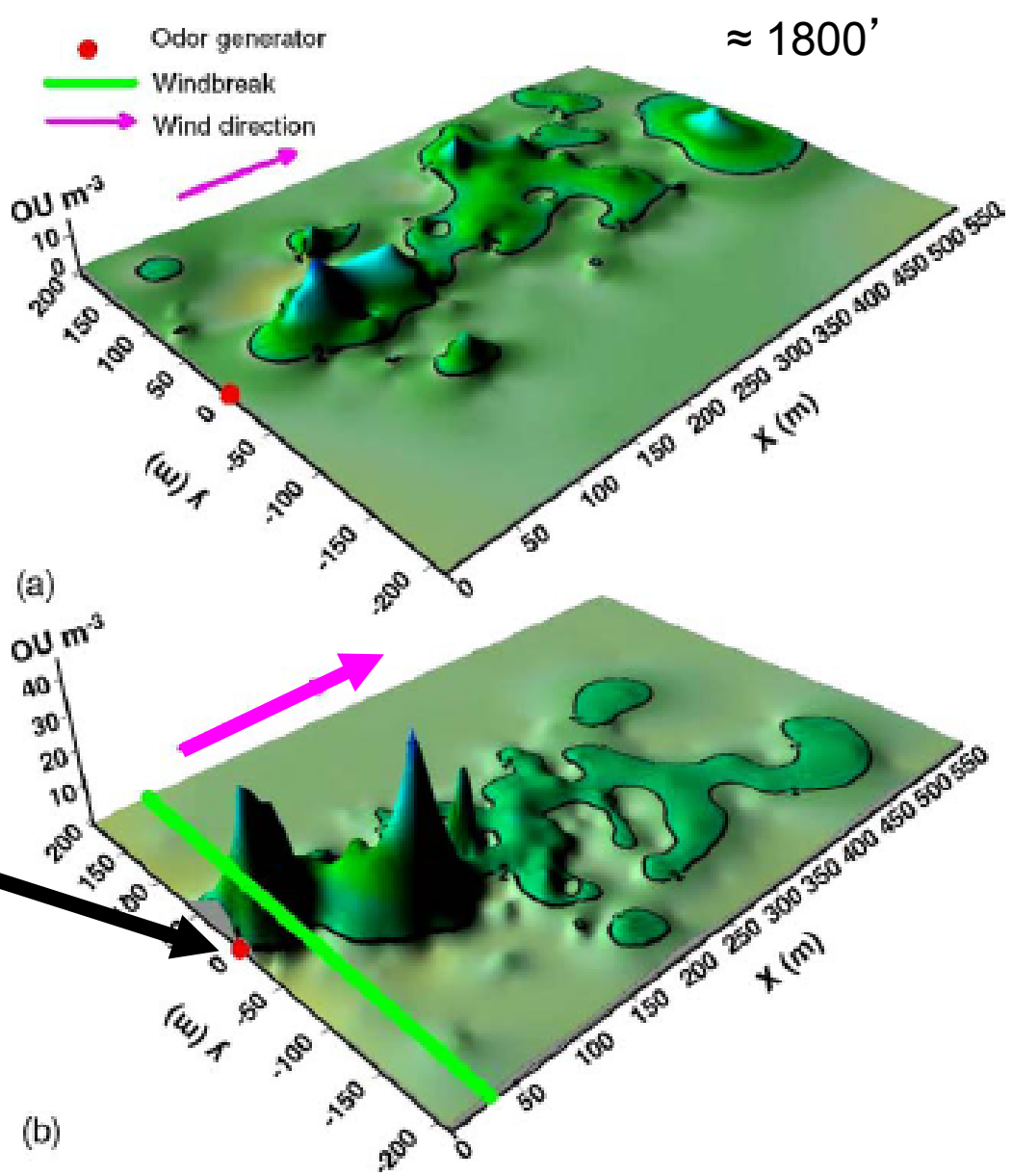


Fig. 4. Odour plumes on sites 2 and 5: (a) without windbreak (tests 37, 38 and 39) and (b) with windbreak on the site 2 (tests 5, 8, 12 and 16). An odour concentration of 2 Ou m^{-3} is used to draw the final contour of the odourous zones.

Lin et al, 2006
McGill University