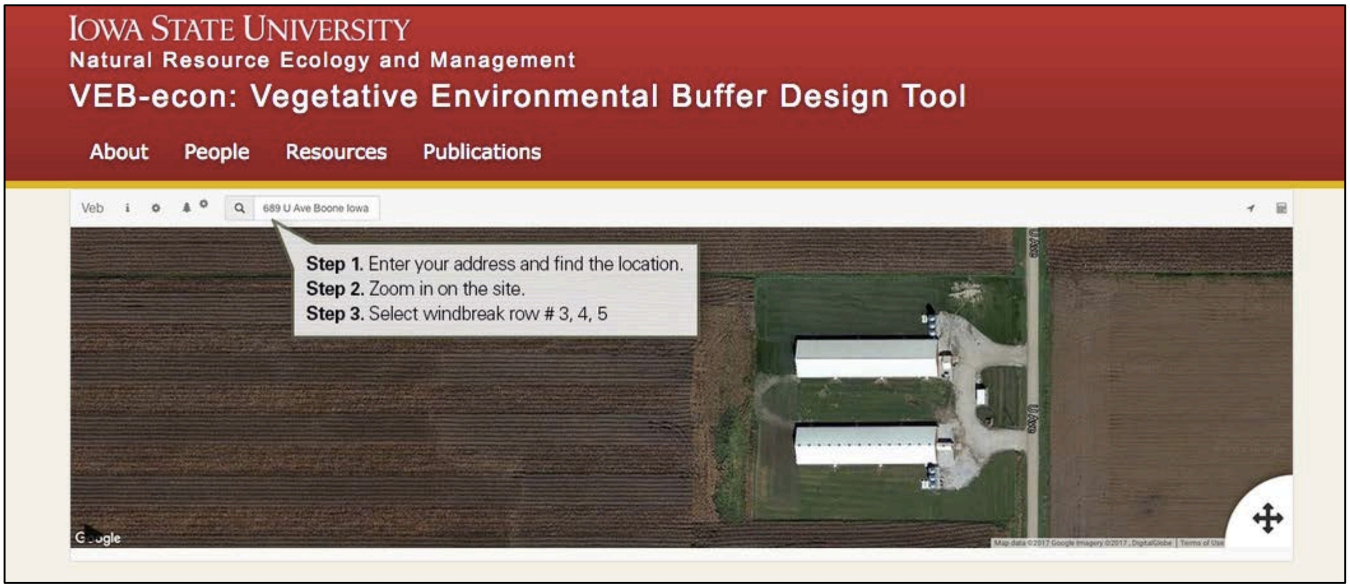
VEB-econ 1.0: Vegetative Environmental Buffer Design Tool Documentation



Available @: https://veb.nrem.iastate.edu/

Vegetative Environmental Buffer Builder and Economic Review:
A Decision Support Tool for the Pork Industry

A Pork Checkoff Funded Research Project: National Pork Board 13-243

John Tyndall and Jesse Randall
Department of Natural Resource Ecology & Management
Iowa State University

2017

VEB-econ 1.0: Vegetative Environmental Buffer Design Tool

This document overviews the context of mitigating animal production odors with Vegetative Environmental Buffers (VEB) and the use of the *VEB-econ* 1.0 – Vegetative Environmental Buffer Design Tool. *VEB-econ* allows users to locate production facilities or future building sites within Google Earth. Users then utilize scaled dimensional drawing tools to delineate property boundaries, roads, animal buildings and other structures, so as to parameterized idealized tree-row locations. Users specify number of desired tree rows, preferred tree-row protection zones, etc. Layered into the mapping tool is the NRCS SSURGO soil database linking tree species recommendations to soil-based tree suitability recommendations.

VEB-econ estimates total annualized costs for tree establishment, long-term management, any opportunity costs and factors in the potential benefit of utilizing available NRCS EQIP cost-share programming for VEBs.

Basic VEB and Odor Mitigation Dynamics

As an odor mitigation technology, Vegetative Environmental Buffers have been shown to incrementally mitigate odors, particulates, and ammonia through a complex of biophysical and social dynamics. As comprehensively overviewed in Tyndall and Colletti (2007), the biophysical VEB dynamics of note are:

1) enhanced dilution/dispersion of odor into lower atmosphere via vertical atmospheric mixing caused by air being pushed upward as well as forced mechanical turbulence (windbreak dynamics);
2) odor filtration through particulate interception and retention. Livestock production odors (e.g., volatile organic compounds) adhere to particulates and tertiary odor management is largely about controlling the movement of particulates;
3) odor/particulate fallout due to reduced wind speeds;
4) adsorption and absorption of ammonia onto and into the plant due to a chemical affinity that ammonia has to the waxy coating on tree leaves.

With regard to more social oriented outcomes of this technology, VEBs have been noted to help subjectively improve site-level aesthetics and soften the visual cues of negative responses to confinement animal production and odor. Anecdotally, VEBs have aided in improved producer/community relations due to their visibility as an odor management technology (Maulsby, 2012).

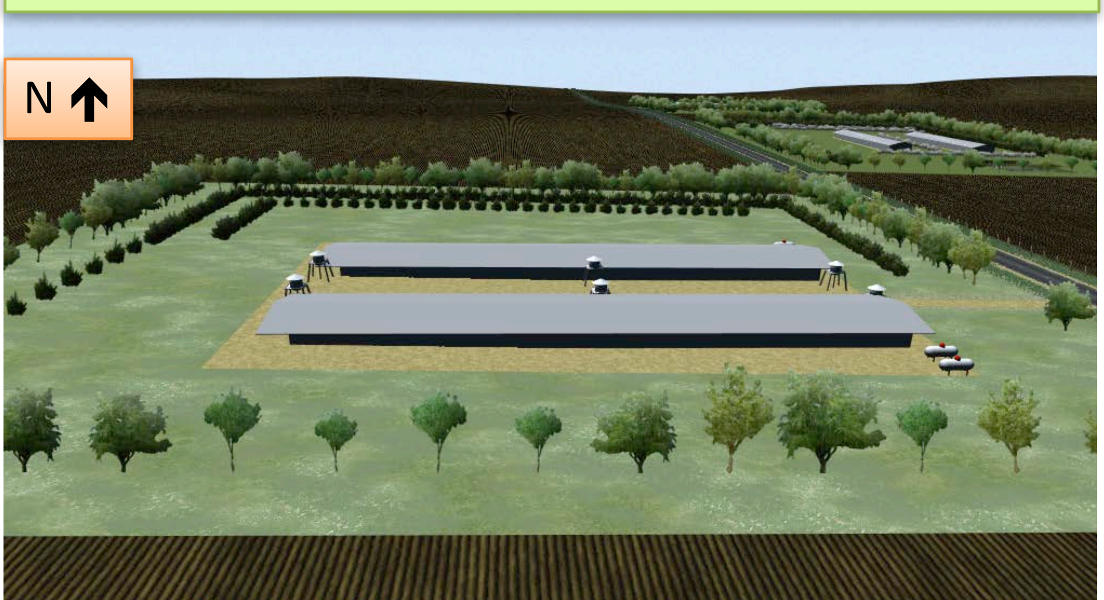
Biophysical Effectiveness of VEBs

The biophysical effectiveness of VEBs in mitigating odor vary considerably from site-to-site due to variation in VEB design, production scale, on-site manure management, and airshed conditions, as well as across time as the trees/shrubs grow larger thus changing/enhancing the VEB/odor interaction dynamics (Tyndall and Colletti 2007). Nevertheless, regional field and laboratory (e.g., wind tunnel) studies have quantified incremental reductions in both particulates and aromatic volatile organic compounds. For example, a recent research review from Liu et al. (2014) summarized five field-based studies noting that VEBs have been shown at various distances to reduce downwind concentrations of: ammonia and dust by up to 50%; hydrogen sulfide (H_2S) by up to 85%; and odorous volatile organic compounds by up to 66%. These incremental reductions in the constituent aspects of odor in turn contribute to odor mitigation by variously reducing the frequency, intensity, duration and subjective offensiveness of odor events (Lin et al., 2006; Tyndall and Colletti 2007).

General VEB Design Issues

When implementing a VEB, there are several key design issues. A proper VEB can serve as both a visual screen and an odor filter. To this end, one needs to account for prevailing summer and winter winds and key visual pathways (e.g., screening a manure storage area from passing traffic). Key planting zones can then be identified so as to maximize the effects of filtration and increased turbulence and provide screening from desired angles and directions.

In Iowa, summer winds generally come from southerly directions, winter winds generally from northerly directions. Tree rows located north of production buildings enhance turbulent dilution effects and particulate filtration during summer months. In the winter snow deposition is a concern, as such the idealized location of tree rows to best manage snow deposition varies depending on number of rows. For 4 or more tree rows, the closest row can be within ~50 ft of the buildings. For 3 rows or less, the closest row can be within ~75 ft.



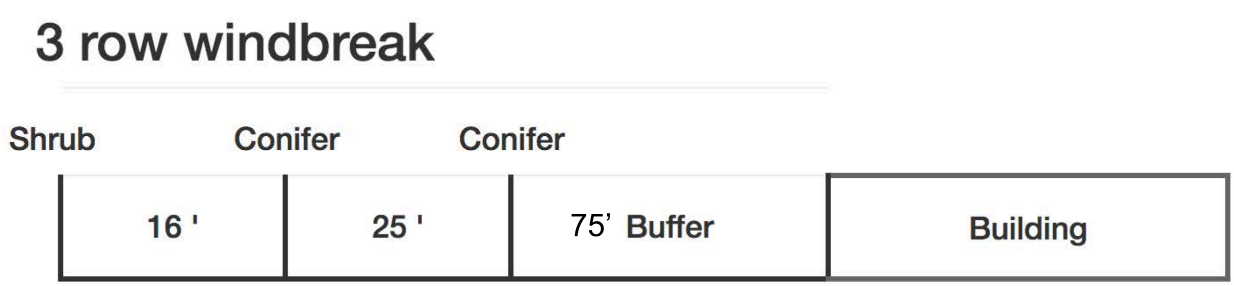
Wider between tree and row spacing south of buildings to allow for summer wind ventilation.

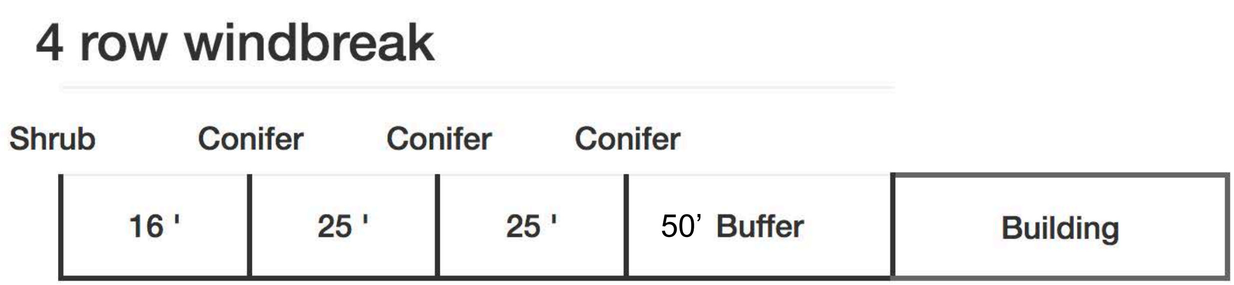
There are three main hazards that must be avoided when utilizing VEBs. Buffer designs need to prevent: 1) winter snow deposition problems caused by planting trees to close to access roads and buildings. In Central Iowa for example winter winds largely come from the North/Northeast. Therefore, VEBs planted to the north of buildings/roads should plan for a planting distance anywhere from 50-200’ away; 2) Trees should not be planted so close to buildings that they prevent appropriate air flow into and out of the buildings. For mechanically ventilated buildings trees can be planted as close as 5-6 times the diameter of the fans and avoid causing back pressure, yet that distance may not be healthy for the trees. A distance of at least 40 feet away from fans has been recommended (Malone et al., 2006). For naturally ventilated systems, one does not want to impede necessary summer winds (which in Central Iowa tend to come from the South/South east) blowing into the buildings; and 3) Traffic visibility into and out of the facility grounds is important, so keep the mature heights of trees in mind when planting trees near access roads.

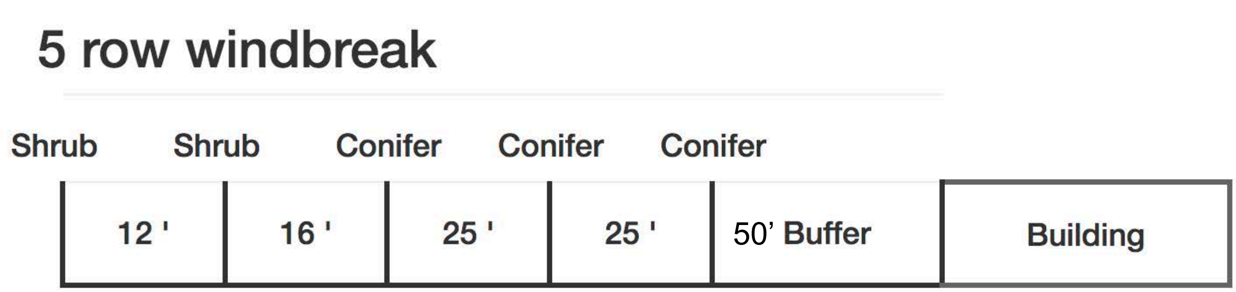
VEB-econ Default Design Settings

Current default settings for tree row distance north of buildings, spacing between tree rows and distance between trees within rows are as follows:

VEB-econ Default VEB Spacing between tree rows



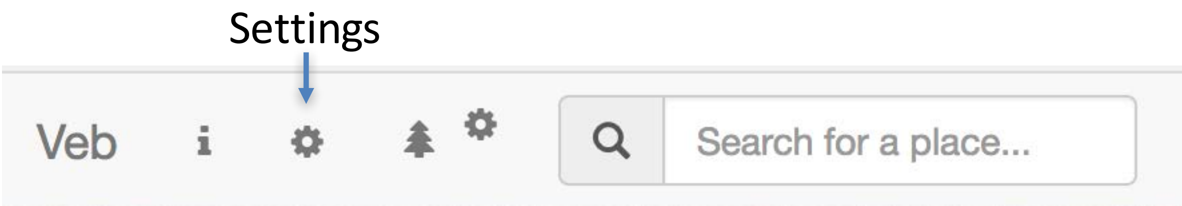




VEB-econ default spacing between trees:

Planting stock size	Spacing (feet between trees)
Bareroot tree seedlings	20’
2-foot and larger containerized trees	30’
Shrubs	6’

Initial VEB designs are subject to *VEB-econ*’s default settings in terms of distance of rows from buildings and spacing between trees within rows. Users can adjust these default settings by accessing the “Settings” option located in the upper left corner of the tool’s web interface (see below).



Soils Data and Iowa Woodland Suitability Planting Recommendations

VEB-econ users select desired tree or shrub species from drop-down menu options that are based on tree/shrub suitability recommendations as determined by a National soil database layer (GIS soil data: NRCS SSURGO). Tree and shrub species recommendations based on soil groups are in accordance with the Iowa Department of Natural Resources (IDNR), Woodland Suitability Recommendations (IDNR, 2014: http://publications.iowa.gov/17411/). The species database also notes when non-native species are selected or when there are known pest and/or pathogen susceptibilities. Compliance with IDNR species recommendations is required if landowners wish to participate in the Environmental Quality Incentive Program (EQIP) and receive cost share support.

Financial Aspects of VEBs

VEB-econ accounts for the following costs per VEB design: 1) Site-preparation costs; 2) tree establishment costs which includes purchasing tree stock and planting costs; 3) long-term maintenance costs which include weed control and periodic site mowing; 4) any opportunity costs such as the cost of capital and, if required, land rent costs; and 5) the estimated financial effects of the Environmental Quality Incentive Payment (EQIP) programming. Below in table 1, the default costs used by *VEB-econ* are itemized.

Cost Data used By VEB-econ

The current launch version of *VEB-econ* is calibrated to Iowa market conditions for nursery stock, custom rates and land values (see table 1), yet input prices can easily be modified by the user and subsequent versions of the software will allow users to select different states (e.g., Iowa, Minnesota, Missouri, Illinois, and Indiana) thus accessing a cost database unique to that state.

Table 1. Default VEB-econ cost actions and data. All costs are in 2017 dollars US. Data updated from Tyndall and Grala, 2010.

Action	Year(s)	Price/ Unit (US 2017 $)
Site Prep if planting in grass [1]		
Plowing (Chisel) - fall	0	$19.15/ acre
Spraying - Fall	0	$7.00/ acre
Spray (roundup)	0	$32.00/ acre
Disking - Spring	0	$15.15/ acre
Site Prep if planting in cropland [1]		
Disking - Spring	0	$15.15/ acre
Spraying - Fall	0	$7.00/ acre
Spray (roundup)	0	$32.00/ acre
Shelterbelt Establishment		
Tree purchase costs	0	Variable; See table 2 below
Shrubs purchase cost	0	Variable; See table 2 below
Tree planting cost	0	$1.00/ tree
Shrub planting cost	0	$1.00/ shrub
Permeable plastic mulch and installation	0	$74.00/ 1000 ft
Drip Irrigation and Installation	0	$700/ acre
Long Term Maintenance		
Tree replanting [2]	3	Variable; 10% of initial planting
Shrub replanting [2]	3	Variable; 10% of initial planting
Tree planting cost	3	$1.00/ tree
Shrub planting cost	3	$1.00/ shrub
Weed control (e.g. mowing)	Annual	$45.00/ hour; mow ~1.3 acres/ hour
Other relevant costs		
Overhead/management [3]	Annual	2% of year 0 costs
Land rent [4]	Annual or 0	Variable; proxy is land rent. Land purchase price is also possible.

[1] Site preparation will vary across sites. In many cases the grounds of a confinement livestock facility - the area where trees are to be planted – feature highly compacted soils, subsurface soil piling, poor drainage, etc. Appropriate site preparation is critical for the long-term health of tree plantings and will contribute toward lower tree mortality, faster tree growth and, ultimately, lower time, money and effort in managing the system over life of the operation. [2] Some tree and shrub mortality should be expected. In Iowa, about 10% mortality of initial planting is typical in otherwise healthy windbreaks; [3] A general rule of thumb for overhead cost is that it is equal to 2% of all year 0 costs; Includes insurance, energy requirements, monitoring time, etc; [4] If any land is taken out of production for the planting of a VEB then land rent should be factored in (this is for any tree planting that occurs off the grassed area in the photo). The average rental rate for the state of Iowa in 2016 was $230/acre (county level averages can be found here: https://www.extension.iastate.edu/agdm/wholefarm/html/c2-10.html.

Nursery Tree and Shrub Stock Pricing

The default costs for planting stock are based on a database of current (2016/2017) regional nursery prices for various sizes of all tree and shrub stock (e.g., bare root stock to containerized). Table 2 below summarizes these costs.

Table 2. VEB-econ default tree and shrub nursery stock pricing. Data is a compilation of prices from five Iowa based tree nurseries; all prices per tree/shrub are based on 2017 pricing catalogs.

Tree/Shrub	Bareroot	Container (18"-24")	Container (2'- 3')	Container (3' - 4')	Container (4" - 5')	Container > 5'
Hybrid willow	$1.03	$6.50	$7.57	$8.65	$11.00	$11.00
Eastern Red Cedar	$3.25	$16.75	$25.00	$35.00	$45.00	$60.00
Conifers (average price across species)	$2.11	$21.00	$25.00	$35.00	$54.00	$65.00
Hardwoods (average price across species)	$1.35	$8.50	$32.50	$35.00	$45.00	$60.00
Shrubs (average price across species)	$1.33	$8.00	$12.00	$14.00	n/a	n/a

Note regarding price data: The cost of nursery stock of any size can vary significantly from this pricing guide due to sales, scale of purchase, timing of purchase, availability, shipping/ transportation costs, etc. The tree and shrub prices used by *VEB-econ* are meant to serve as general baselines. Baseline nursery prices will be updated annually.

Environmental Quality Incentive Program:
Practice Code 380 (Windbreak/ Shelterbelt Establishment)

The Environmental Quality Incentive Program (EQIP; administered by the Natural Resource Conservation Service) provides cost share funding for eligible farmers, for the establishment of Vegetative Environmental Buffers. The program utilizes Practice Code 380 for windbreak/ shelterbelt establishment for, "...any area where woody plants are desired and can be grown and where wind, noise, air quality, or visual problems are a concern." Table 3 presents the Iowa EQIP 2017 Payment Schedule for Practice Code 380.

Table 3. Iowa EQIP 2017 Payment Schedule for Practice Code 380*

Variant	Variant Description	Payment ($/foot)
380-1	3 row windbreak, containerized planting stock	$3.05
380-3	3 row windbreak, bareroot seedling planting stock	$0.90
380-5	1 row windbreak, containerized tree planting stock	$0.60
380-7	1 row windbreak, containerized shrub planting stock	$1.91
380-9	1 row windbreak, bareroot tree seedling planting stock	$0.28
380-11	1 row windbreak, bareroot shrub seedling planting stock	$0.40

*Practice must be maintained for at least 15 years; Payment rate is based on 50% of the estimated incurred costs and foregone income (if applicable) associated with practice implementation. For Historically Underserved producers, which Includes, Beginning Farmers/Ranchers, Limited Resource Farmers/Ranchers, Socially Disadvantaged Farmers/Ranchers, Tribal Farmers/Ranchers and Veteran Farmers/Ranchers, the payments per unit are 25% to 40% higher.

For more information regarding EQIP opportunities for Vegetative Environmental Buffers in your county, please go to: https://www.nrcs.usda.gov/wps/portal/nrcs/main/ia/programs/financial/eqip/

General Cost Calculation Methodology

All costs are summed and discounted when appropriate using standard discounting formulation as per Tyndall and Grala (2009). Total discounted costs for each design are then annualized using a capital recovery factor. A twenty-year analysis is the default planning horizon, as the average life span of typical animal production facility ownership has been estimated to be between 15 and 20 years (ISU, 1998). *VEB-econ* uses a 2% real discount rate following the EPAs recommended discount rate for environmental quality projects that involve only costs (Tyndall and Roesch 2014).

Please note that the direct and indirect cost of any Best Management Practice can vary considerably from site to site and are largely contingent on: initial conditions, weather, soils, crop, practice design, management characteristics and experienced opportunity costs (which can be highly variable). As with all of these types of financial assessments, the costs presented by *VEB-econ* are simply baseline numbers and are meant to be informative rather than prescriptive.

Note Regarding *VEB-econ* Software

Our technology team has created a fully functional beta version of the tool that operates across front and back-end technologies suitable for modern browsers and on modern devices (e.g., Apple Ipad and Android -based tablet devices). The tool is coded via AngularJS, a JavaScript framework as the front-end technology and Drupal as the back-end technology. Drupal is an open source content management framework written in state of the art "server-side" scripting language called PHP which is designed particularly for web development. A mapping application programming interface (API; this specifies how our chosen software components will interact with each other) joined to create a unified and interactive interface. Google Earth provides the mapping data.

References

Iowa Department of Natural Resources (2014) *2014 Iowa Woodland Suitability Recommendations, February 6, 2014.* Available at: http://publications.iowa.gov/17411/

Lin, X. J., Barrington, S., Nicell, J., Choiniere, D., & Vezina, A. (2006) Influence of windbreaks on livestock odour dispersion plume in the field. *Agriculture, ecosystems & environment*, *116*(3), 263-272.

Liu, Z., Powers, W., & Mukhtar, S. (2014) A review of practices and technologies for odor control in swine production facilities. *Appl. Eng. Agric*, *30*(3), 477-492.

Maulsby (2012) Rooted in the future: Blair family values green farmstead program. FarmNews. June 1, 2012. Online at: http://www.farm-news.com/page/content.detail/id/503225/Rooted-in-the-future.html?nav=5005. Last accessed 1-30-17.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. U.S. General Soil Map (STATSGO2). Available online at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627. Last Accessed 1-30-17.

Tyndall JC, Colletti JP. (2007) Mitigating Swine Odor with Strategically Designed Shelterbelt Systems: A Review. *Agroforestry Systems*. 69(1):45-65.

Tyndall JC, Grala RC. (2009) Financial Feasibility of Using Shelterbelts for Swine Odor Mitigation. *Agroforestry Systems* 76:237–250.

Tyndall JC, Larsen GL Drake (2013) Vegetative Environmental Buffers for Odor Mitigation. Pork Information Gateway. - US Pork Center of Excellence. PIG 10-2-15.

Tyndall JC, Roesch G. (2014). A Standardized Approach to the Financial Analysis of Structural Water Quality BMPs. *Journal of Extension*. Vol. 52, Num. 3, 3FEA10.